Climate change in Cyprus: projections from regional climate model simulations

Panos Hadjinicolaou

National Workshop
"Building capacities to cope with health impacts of climate change"
Cyprus, 1st September, 2009

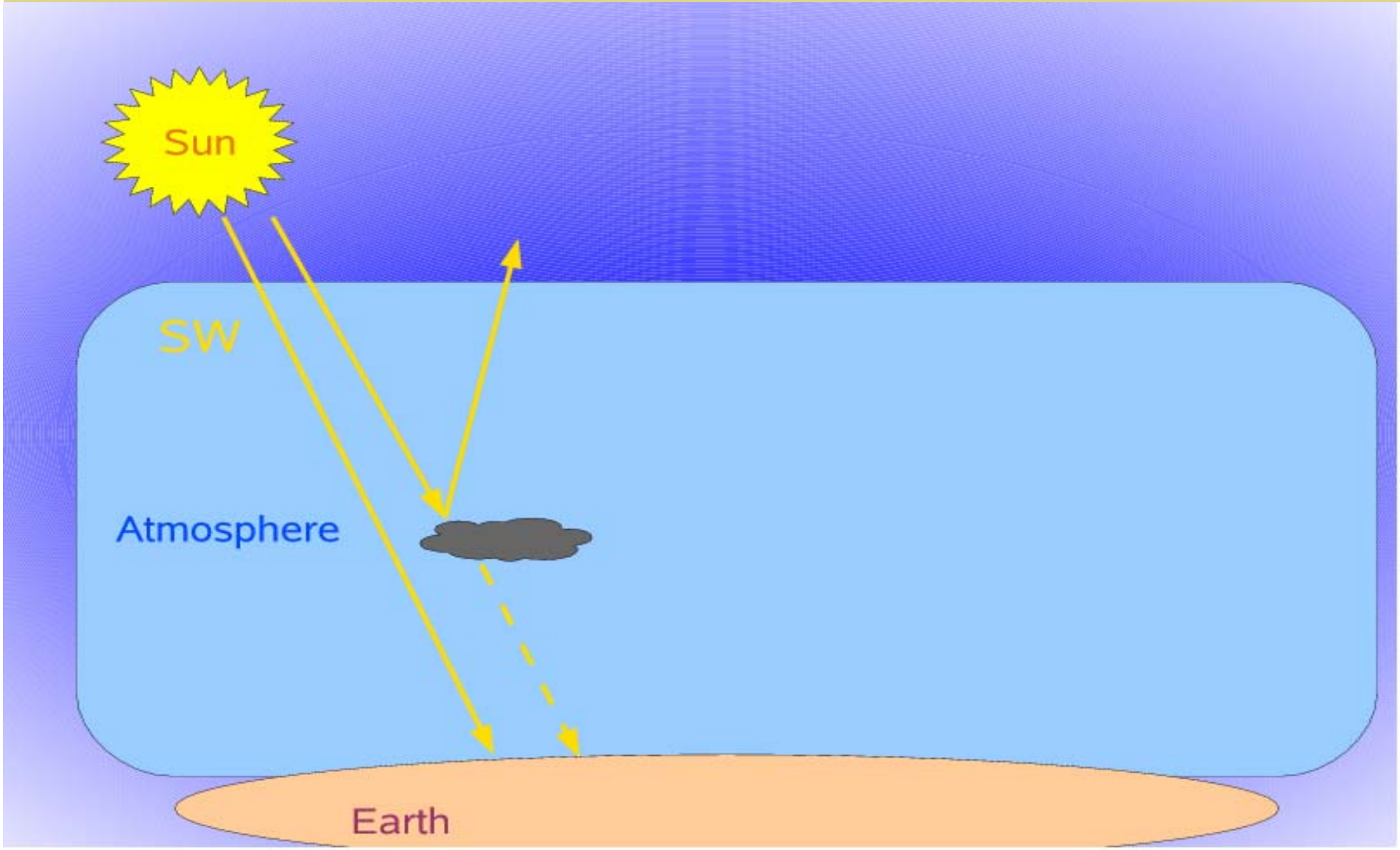
The Cyprus Institute

EEWRC

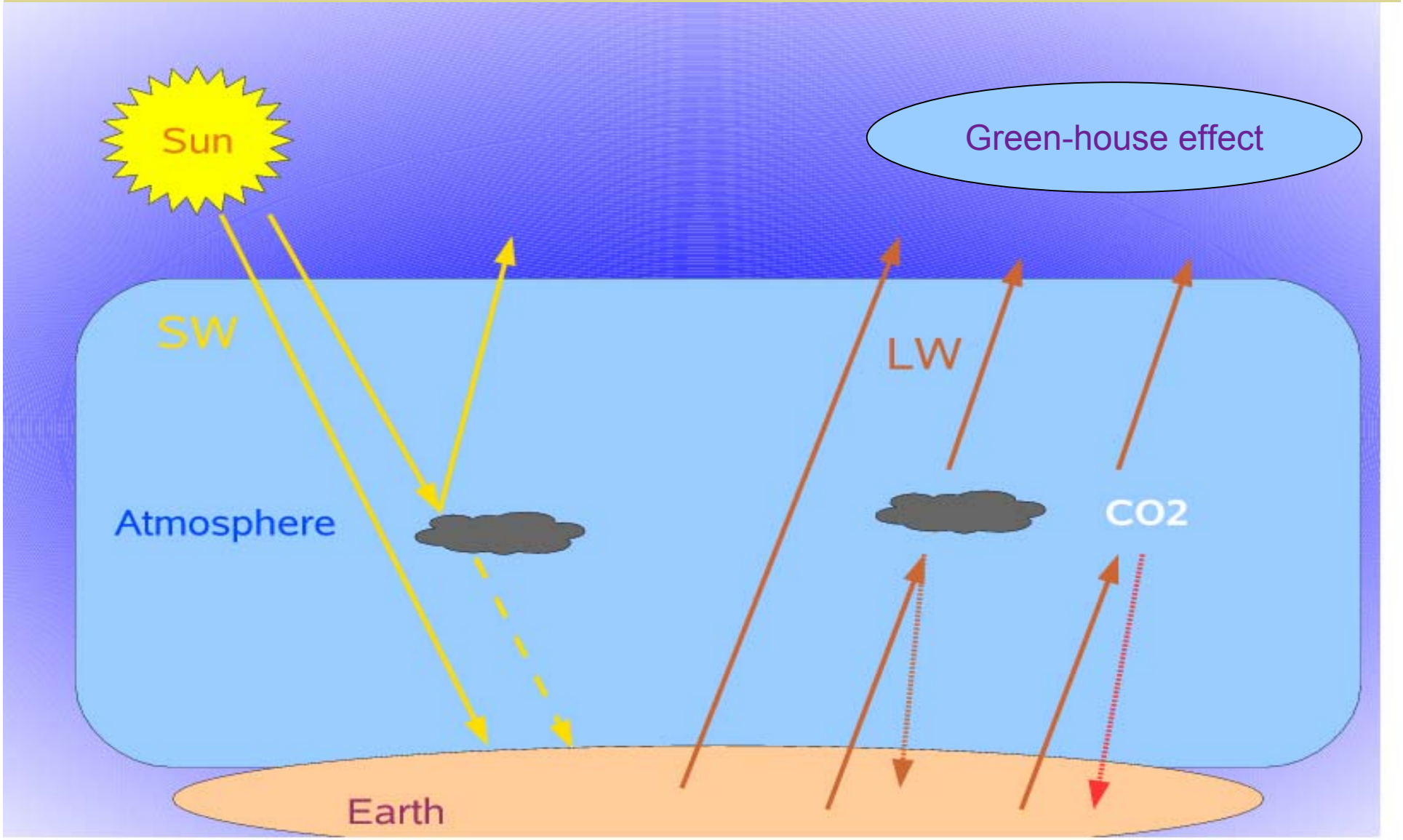
Outline

- Climate change basics
- Climate modelling
- Projections for Eastern Mediterranean
- Extremes over Cyprus
- Other atmospheric hazards linked to climate change
- Conclusions

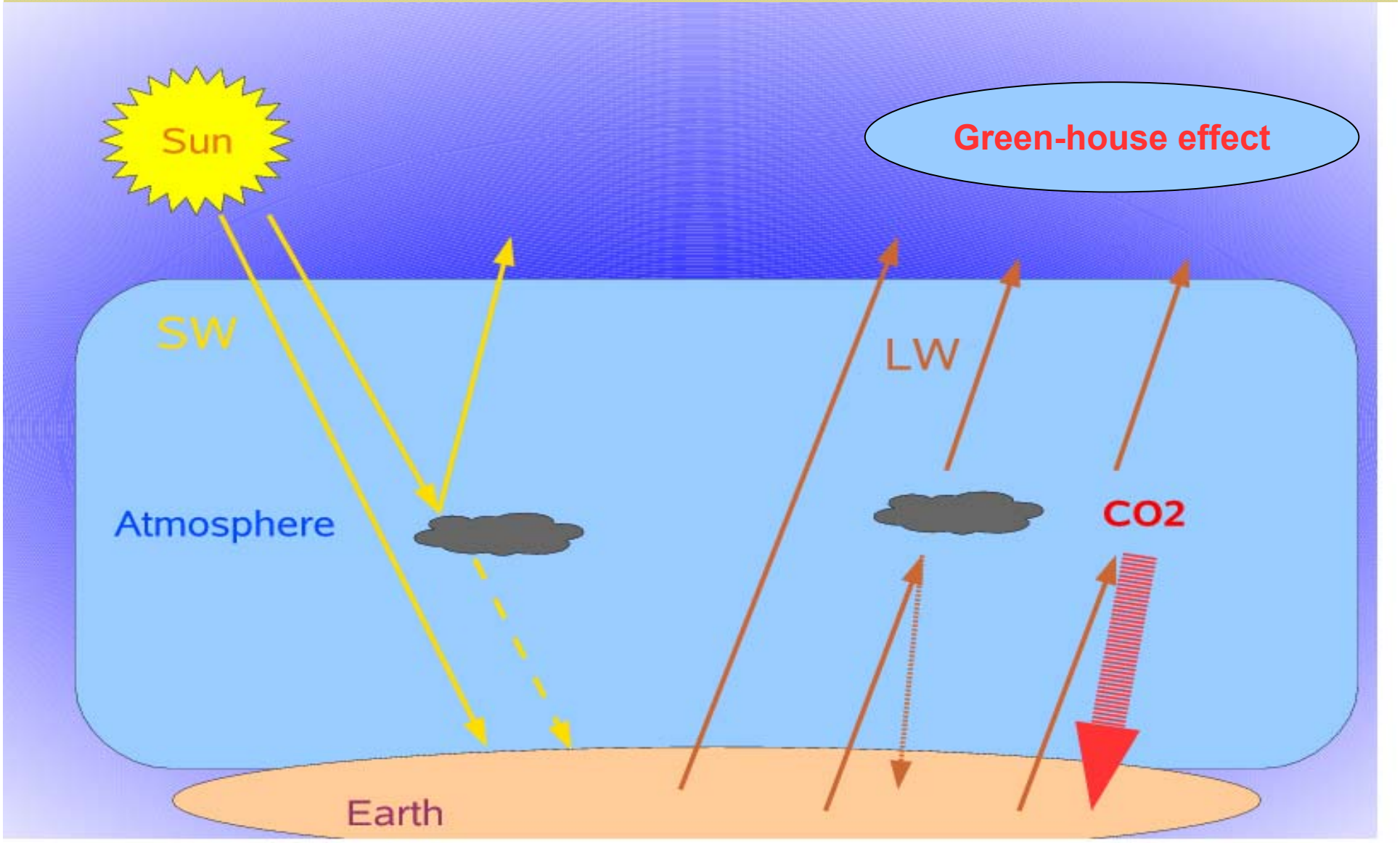
Energy balance: Equilibrium



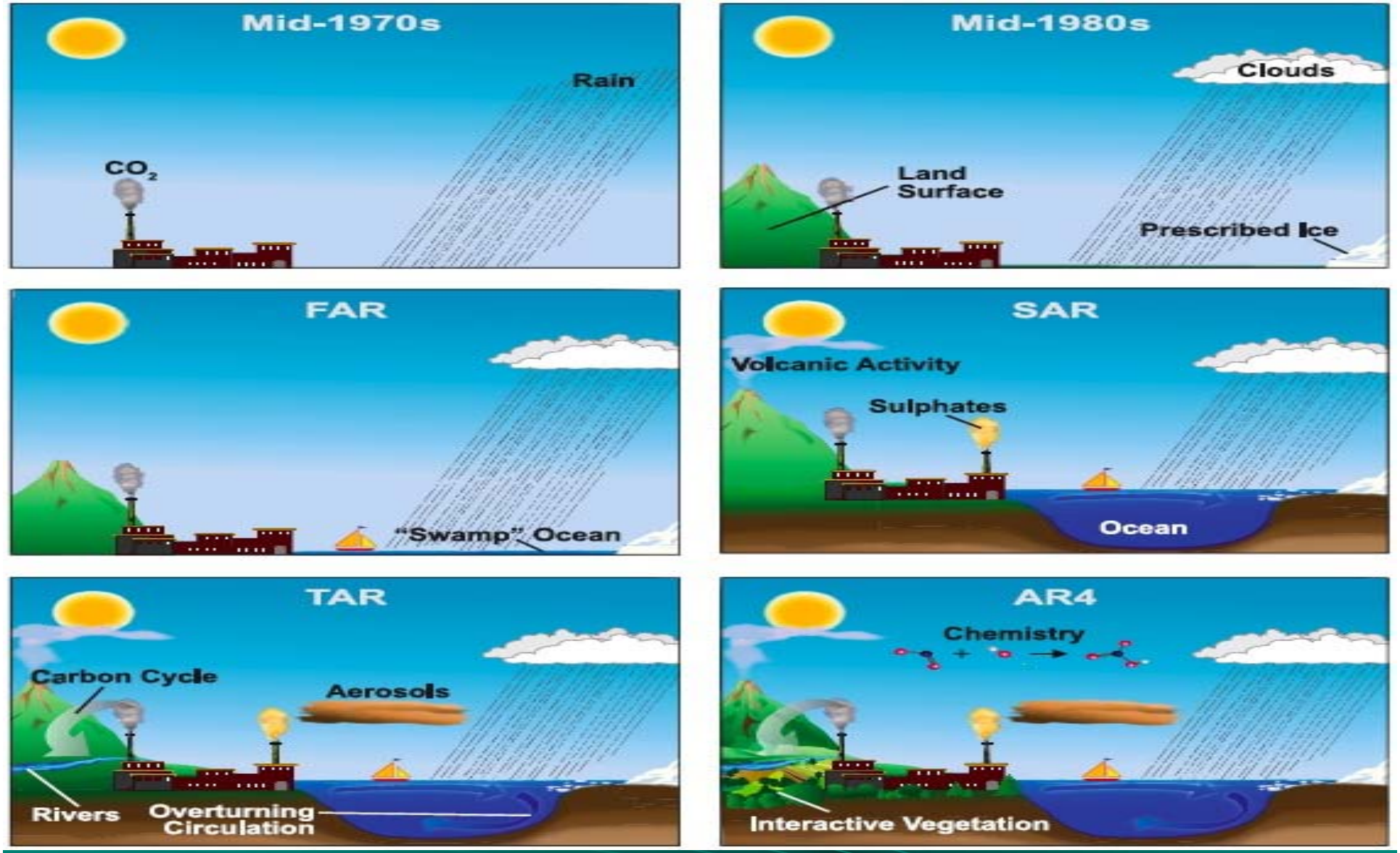
Energy balance: Equilibrium



Energy balance: Perturbation

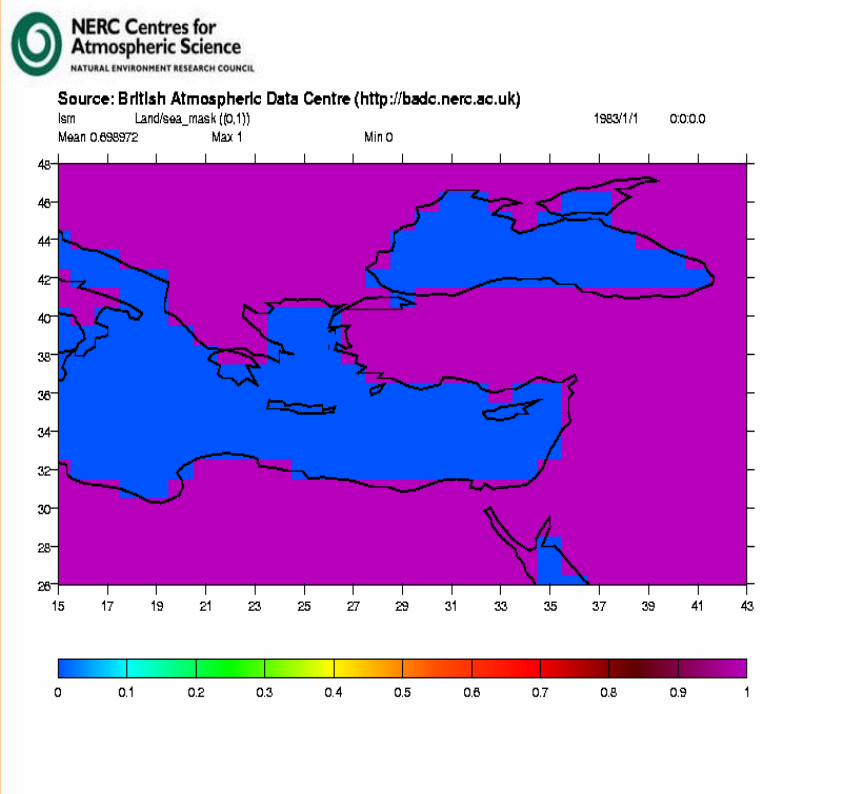


Climate model evolution

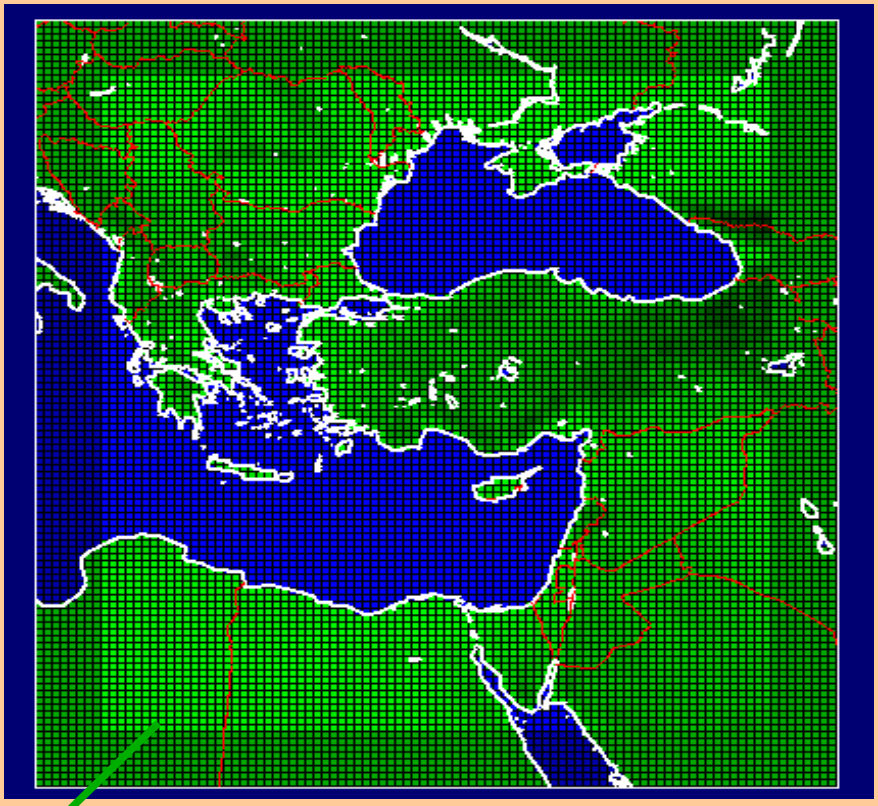


Dynamical Downscaling: land mask

~ global-scale model (GCM)

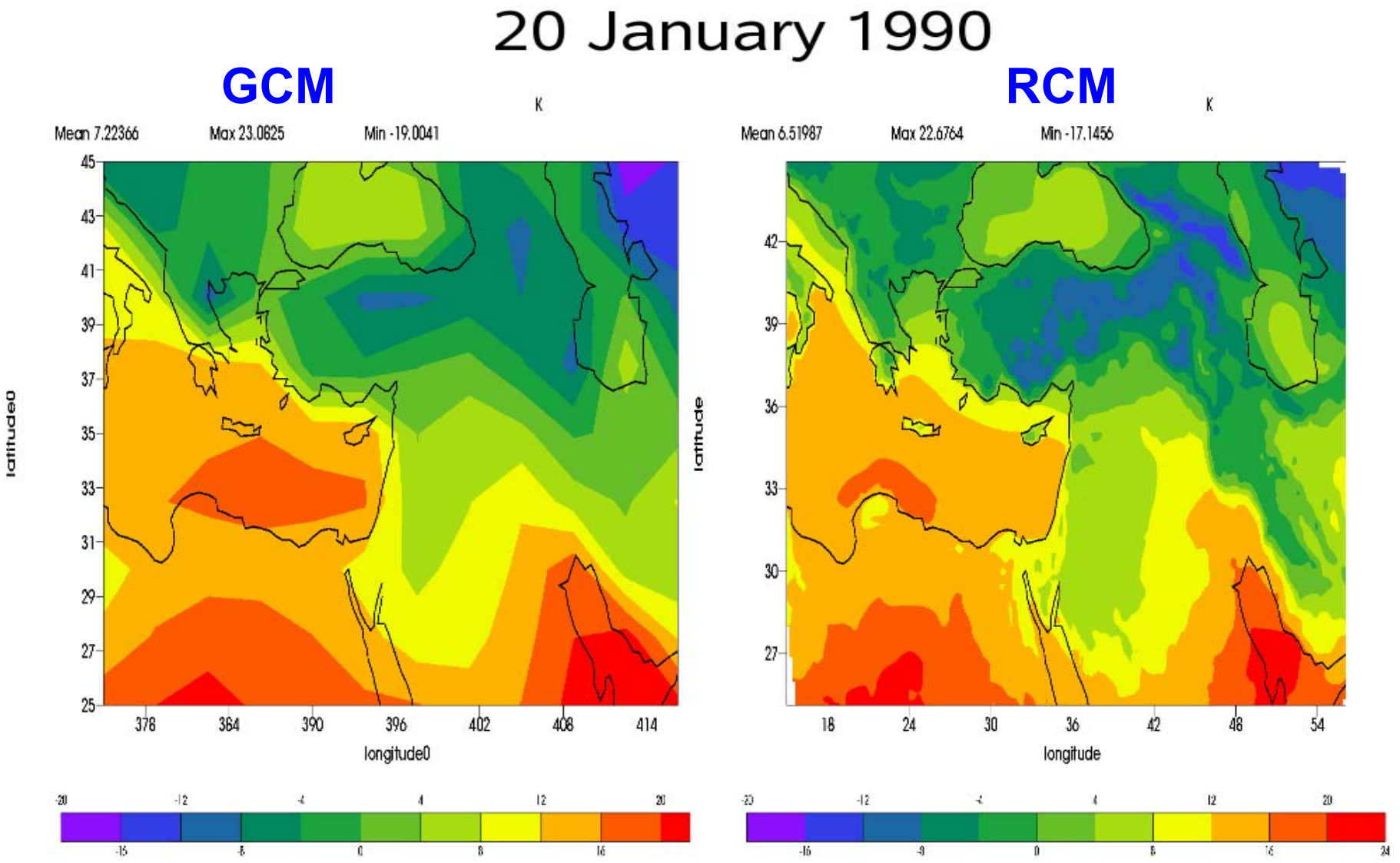


regional-scale model (RCM)



Better representation of coastlines and islands

Dynamical Downscaling: detail



CIMME project in CyI

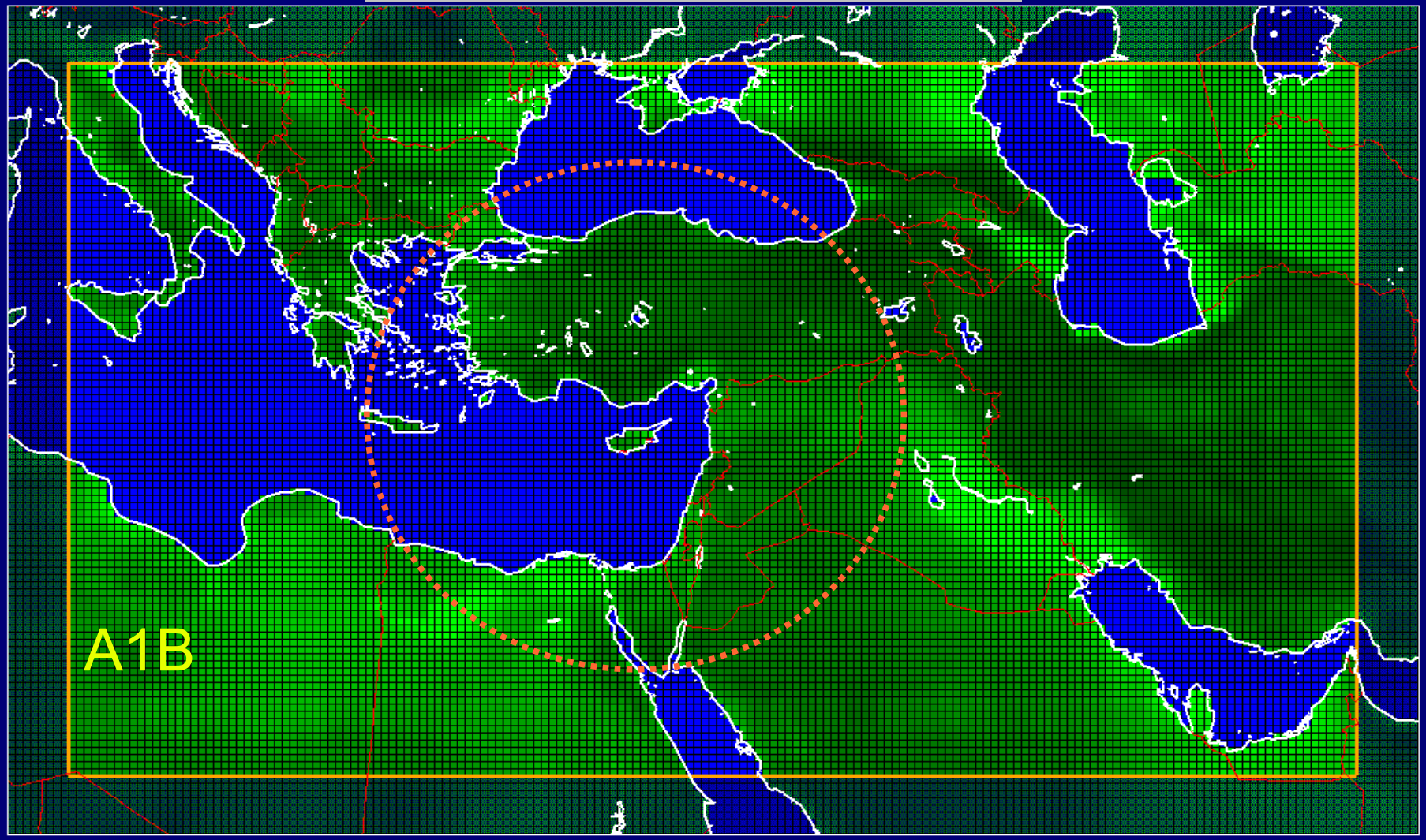
- Climate Change Impacts in the East. Mediterranean/Middle East
- Funded by CyI
- International collaboration
- Cyprus, neighbouring countries and beyond
- Topical reports
- Leader: Prof. Jos Lelieveld, Coordinator: Dr Elena Xoplaki

CIMME Topical Reports

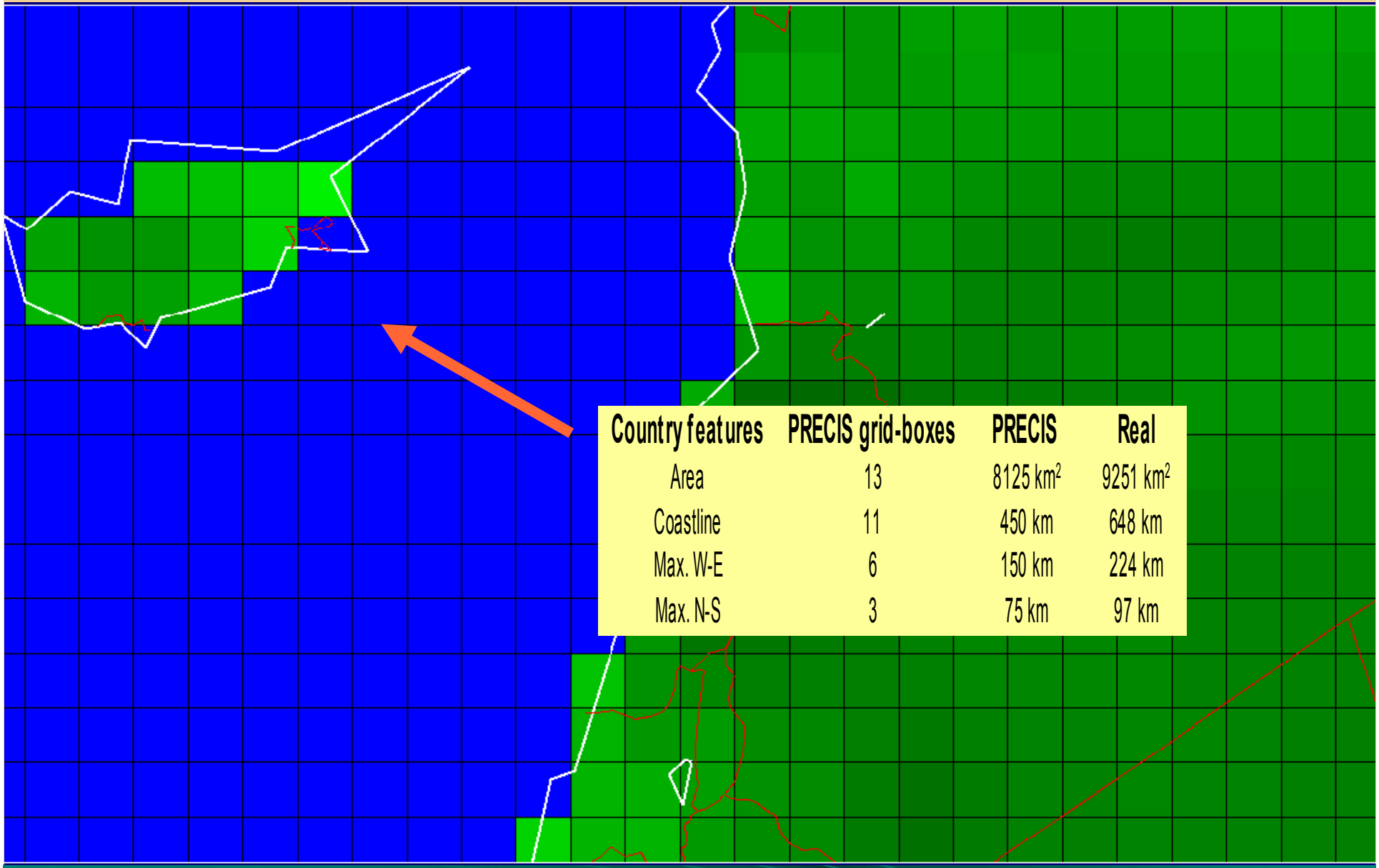
- Climate Assessment (Climate data collection, Climate projections-dynamical/statistical downscaling)
- Energy (Electricity demand, wind potential)
- Water (Regional water balances, weather modification)
- Air Quality (natural/anthropogenic effects)
- Health (Heat related mortality)

PRECIS CIMME East. Med. Mid. East domain

25 x 25 km

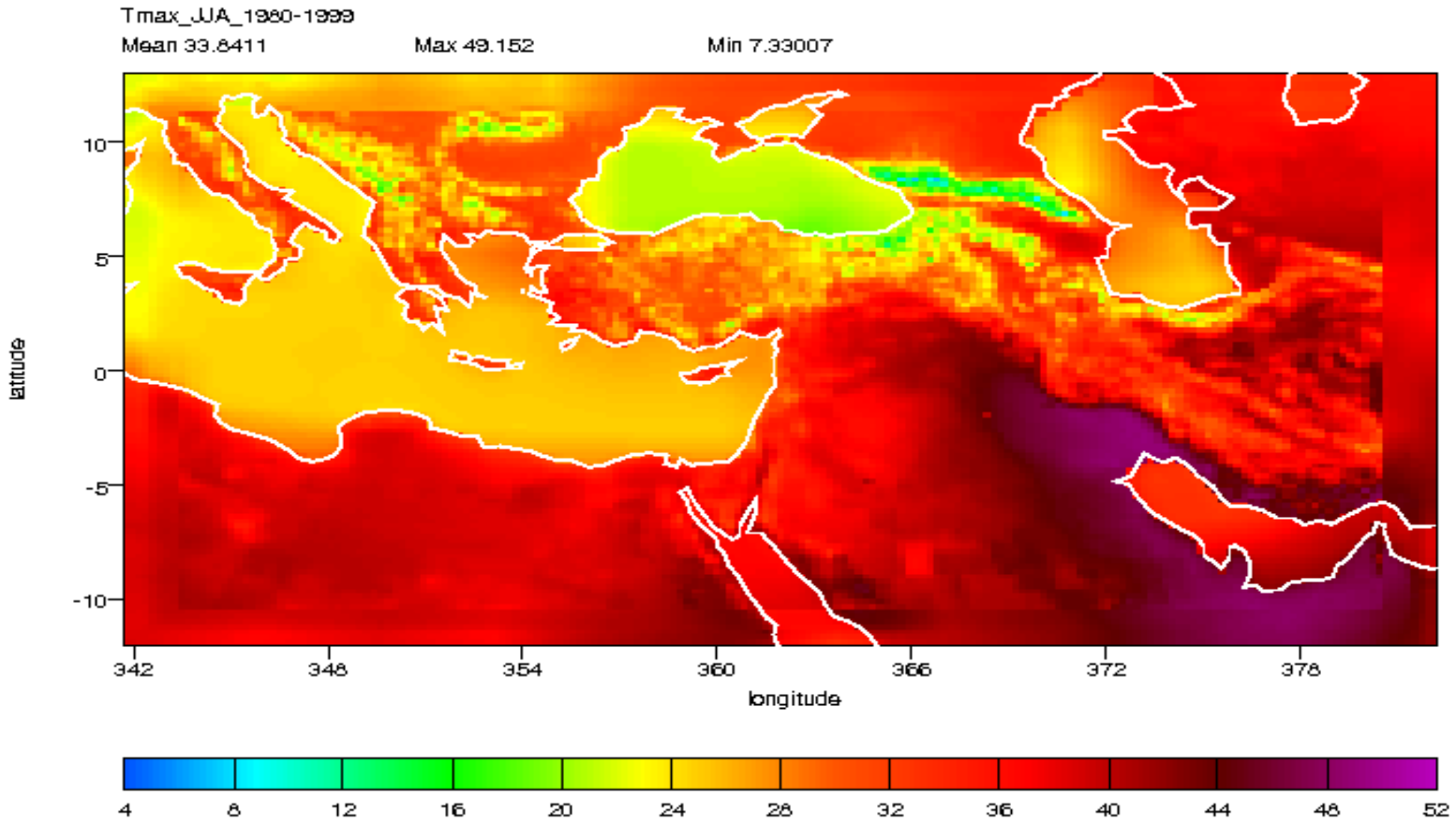


PRECIS CIMME small country domain

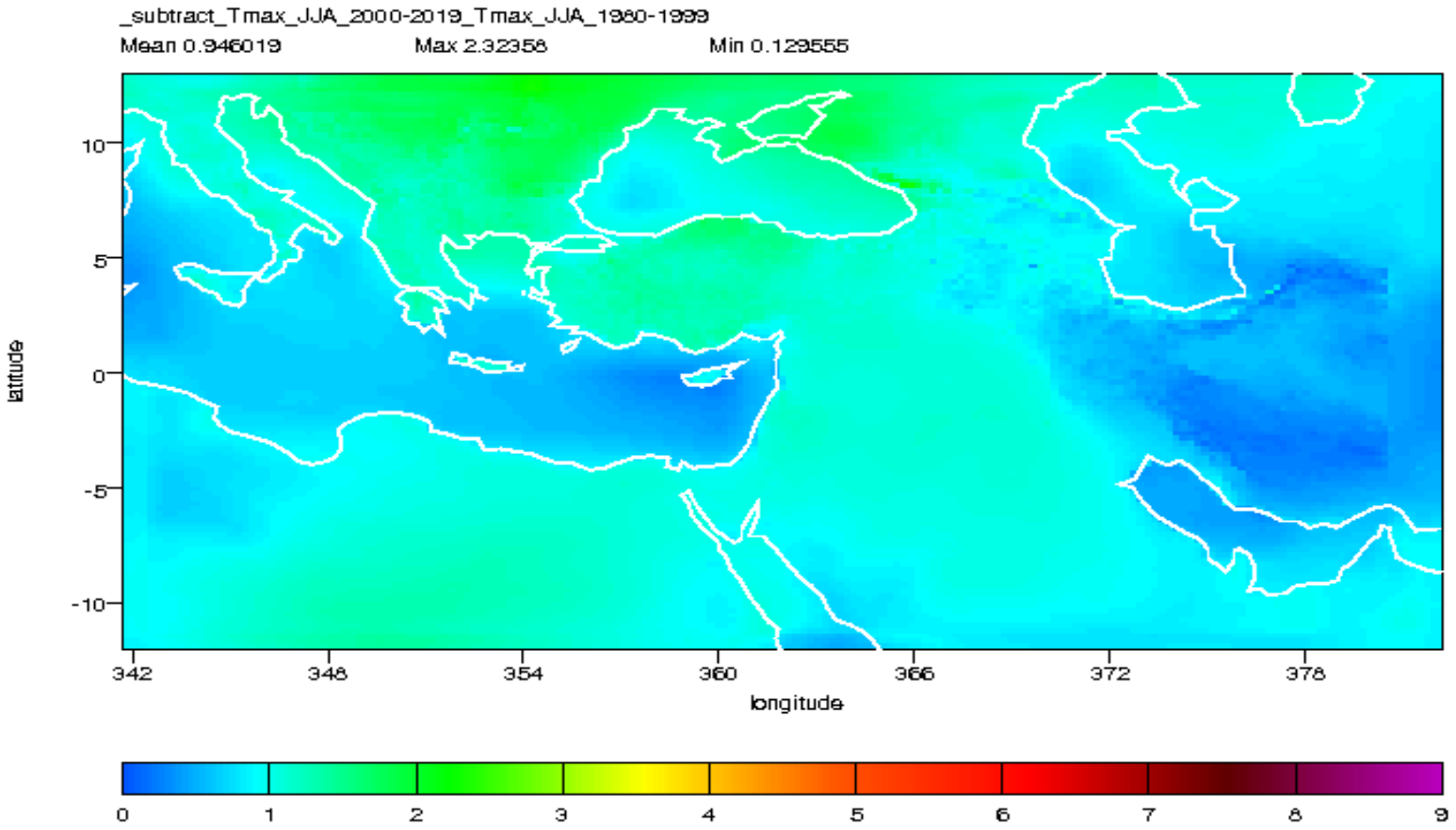


Country features	PRECIS grid-boxes	PRECIS	Real
Area	13	8125 km^2	9251 km^2
Coastline	11	450 km	648 km
Max. W-E	6	150 km	224 km
Max. N-S	3	75 km	97 km

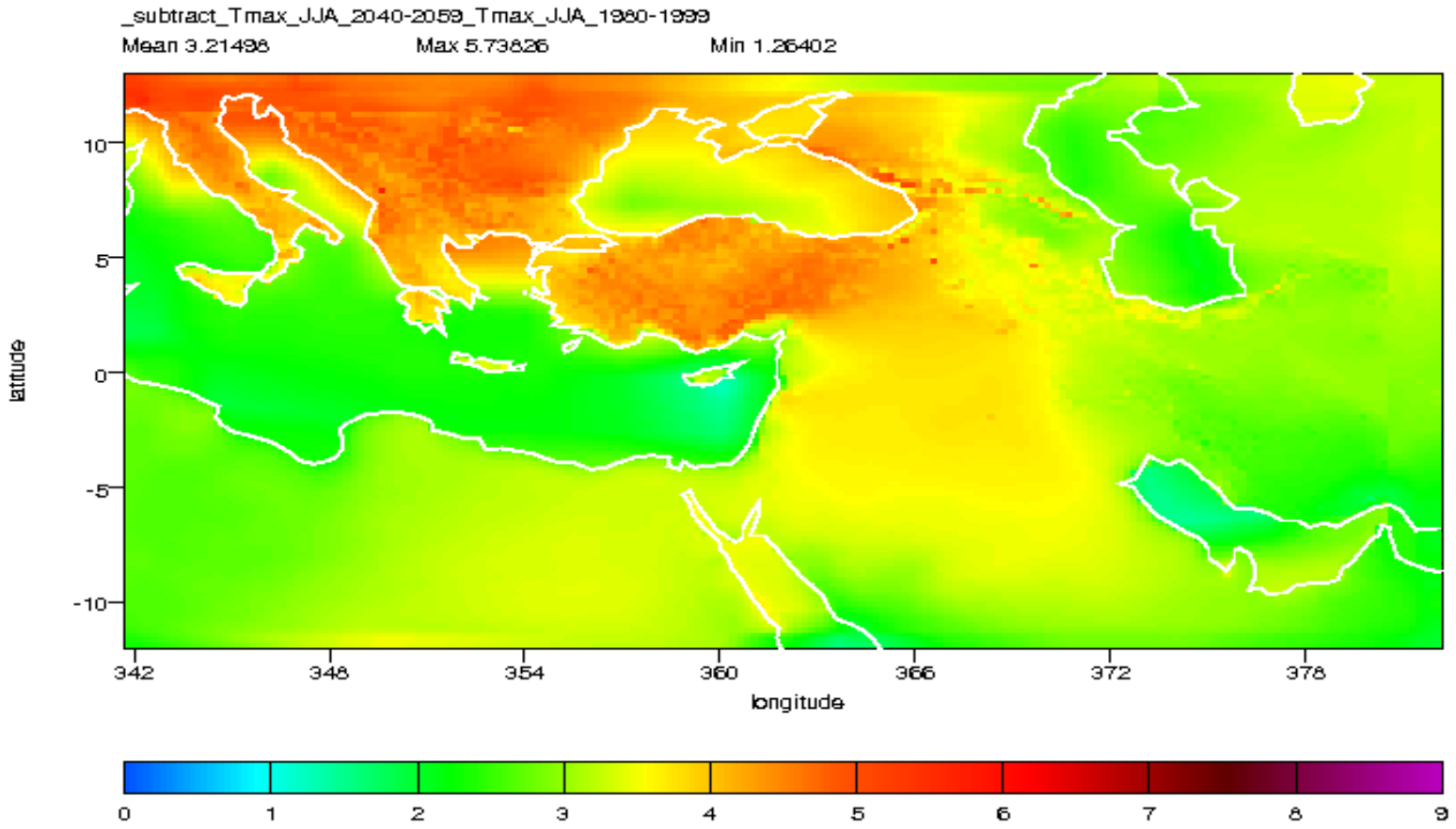
PRECIS Tmax JJA 1980-1999



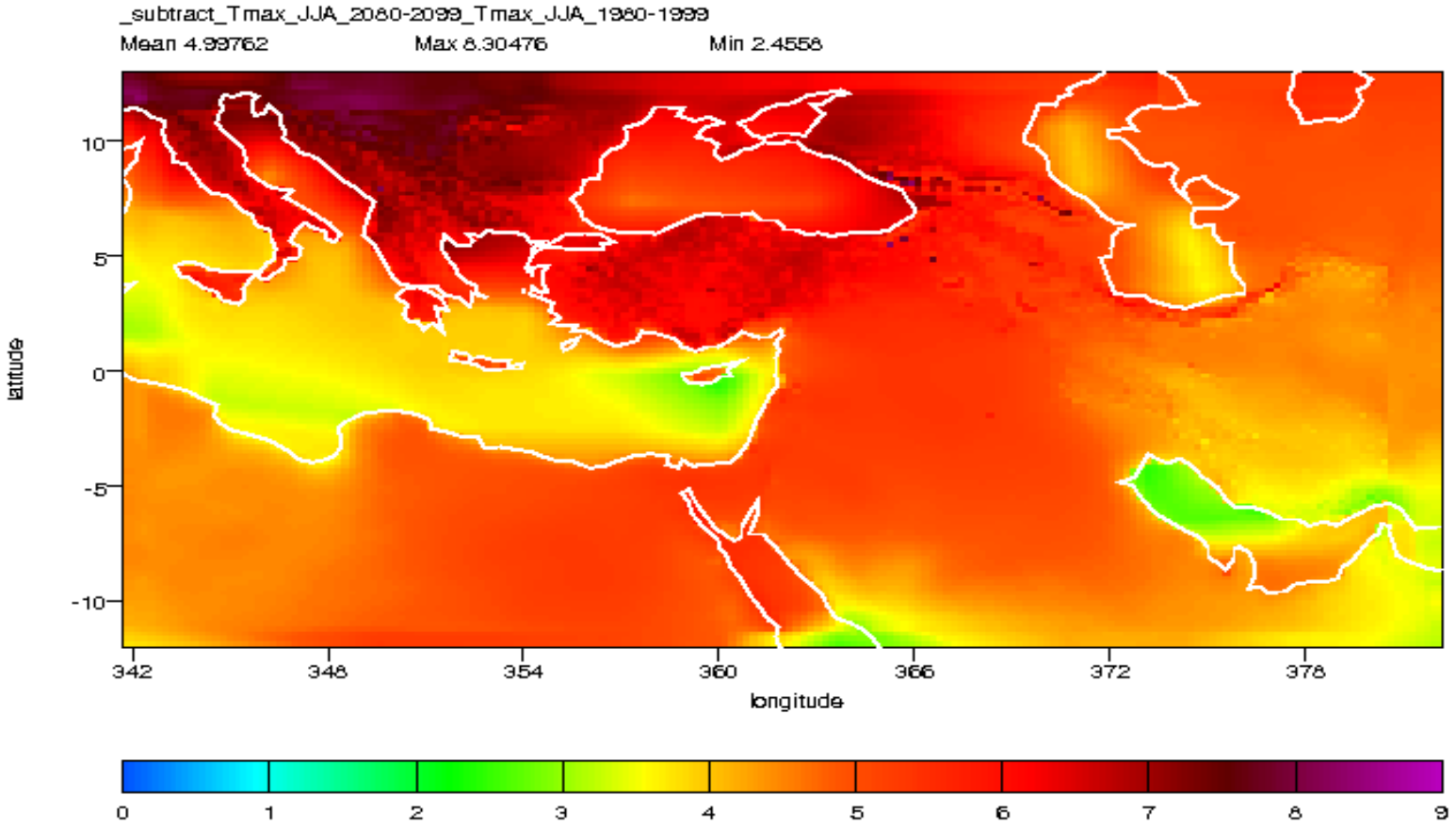
ΔTmax JJA 2000-2019



ΔTmax JJA 2040-2059



ΔTmax 2080-2099



Annual Temperature Nicosia

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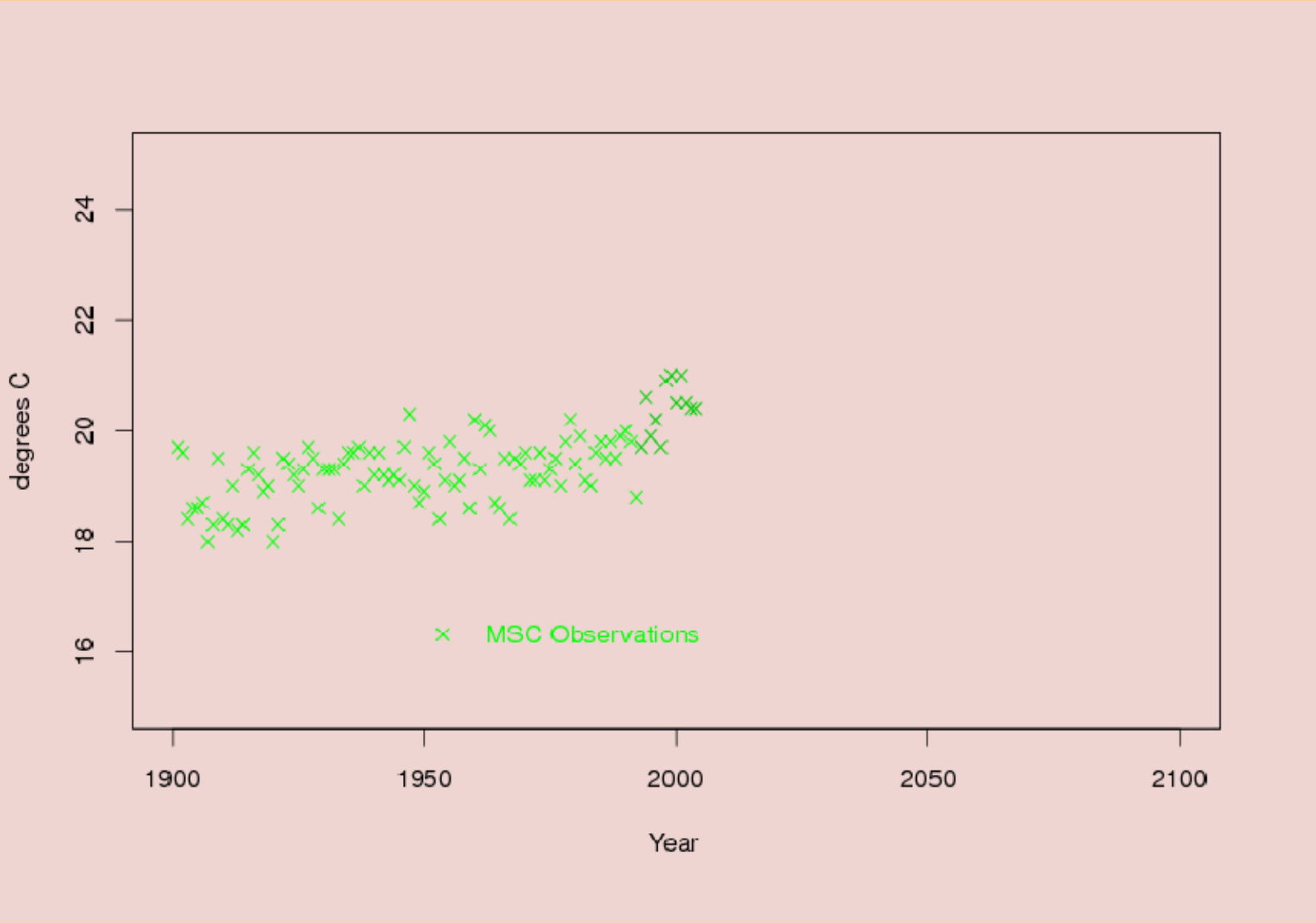

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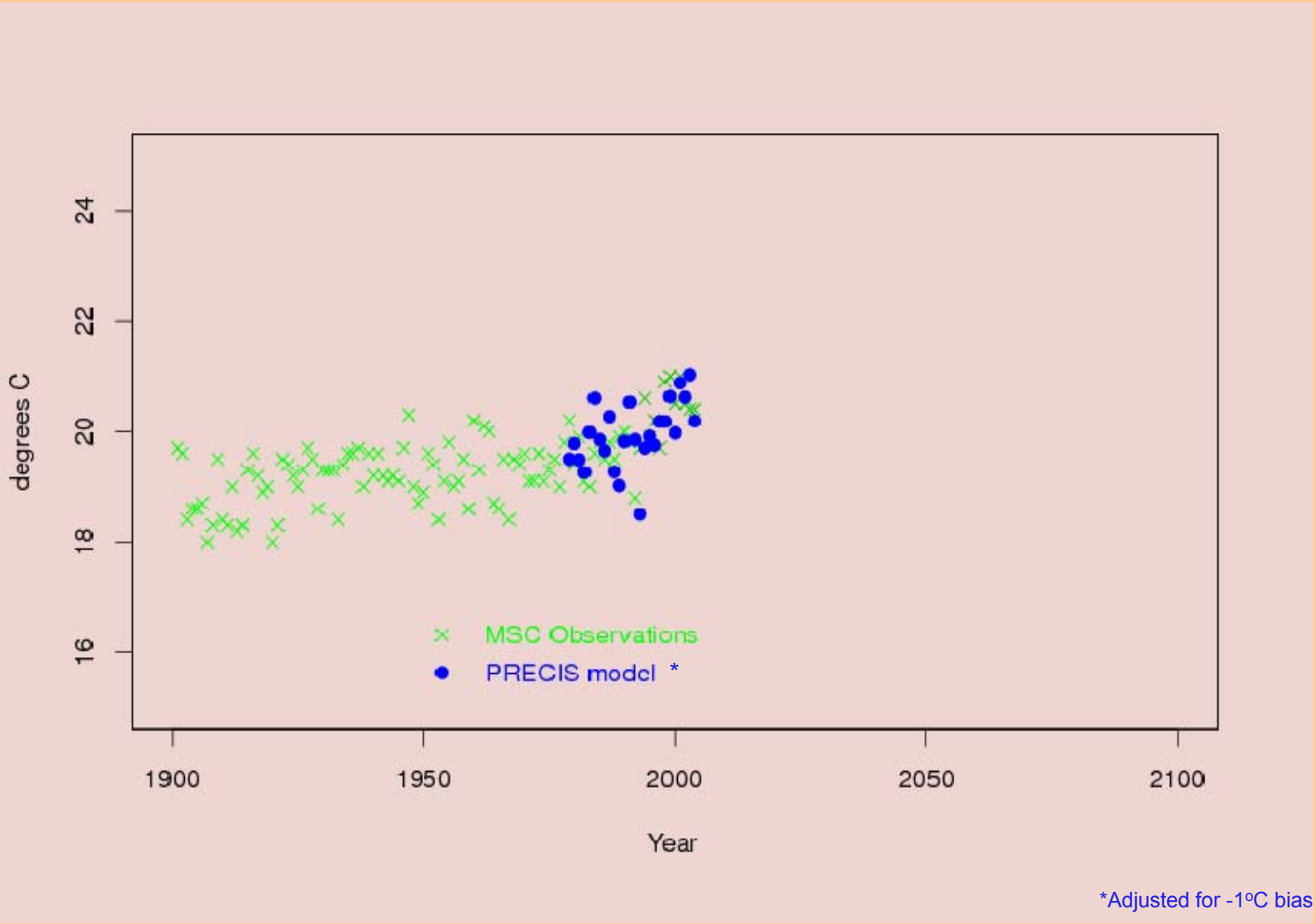
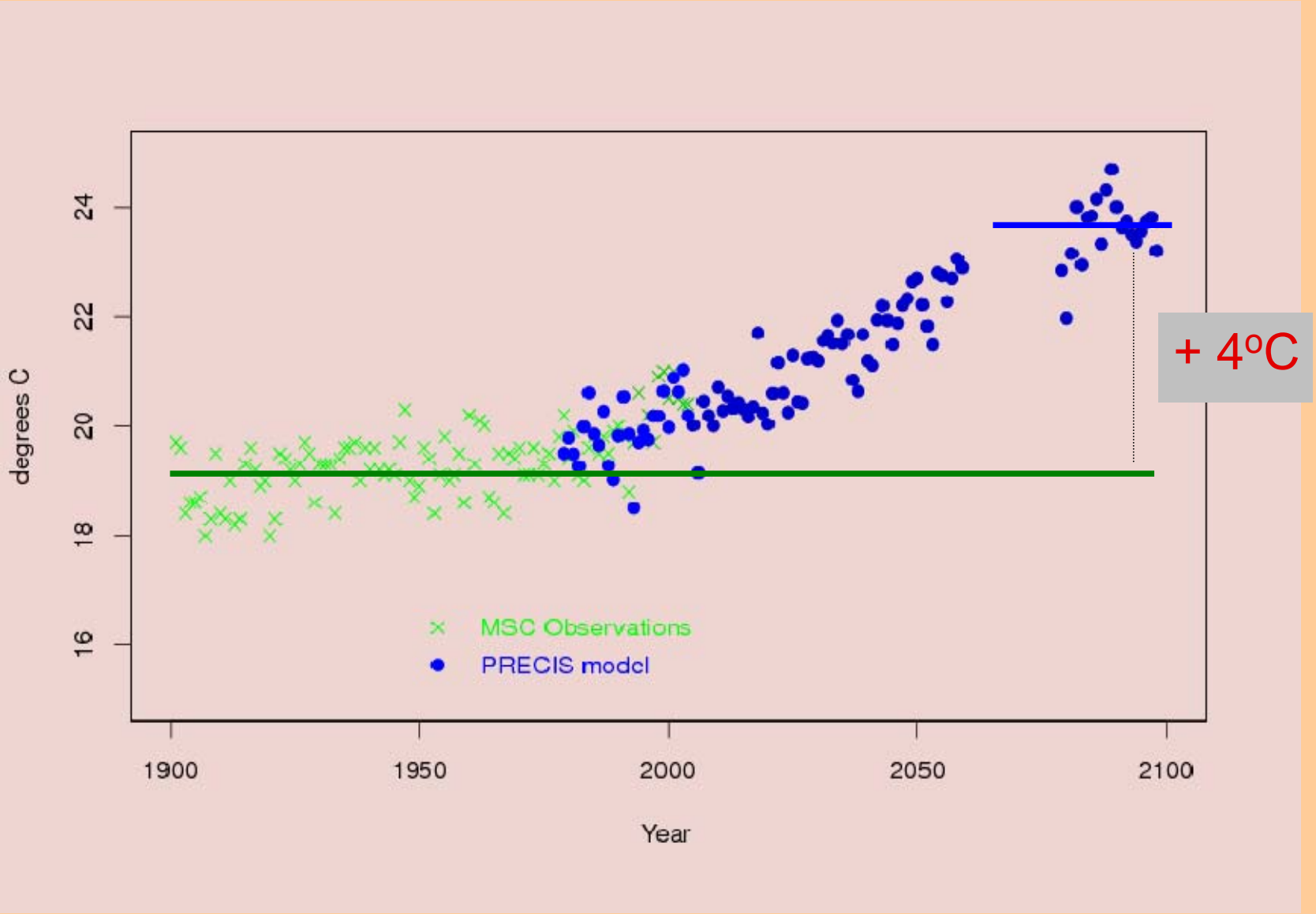
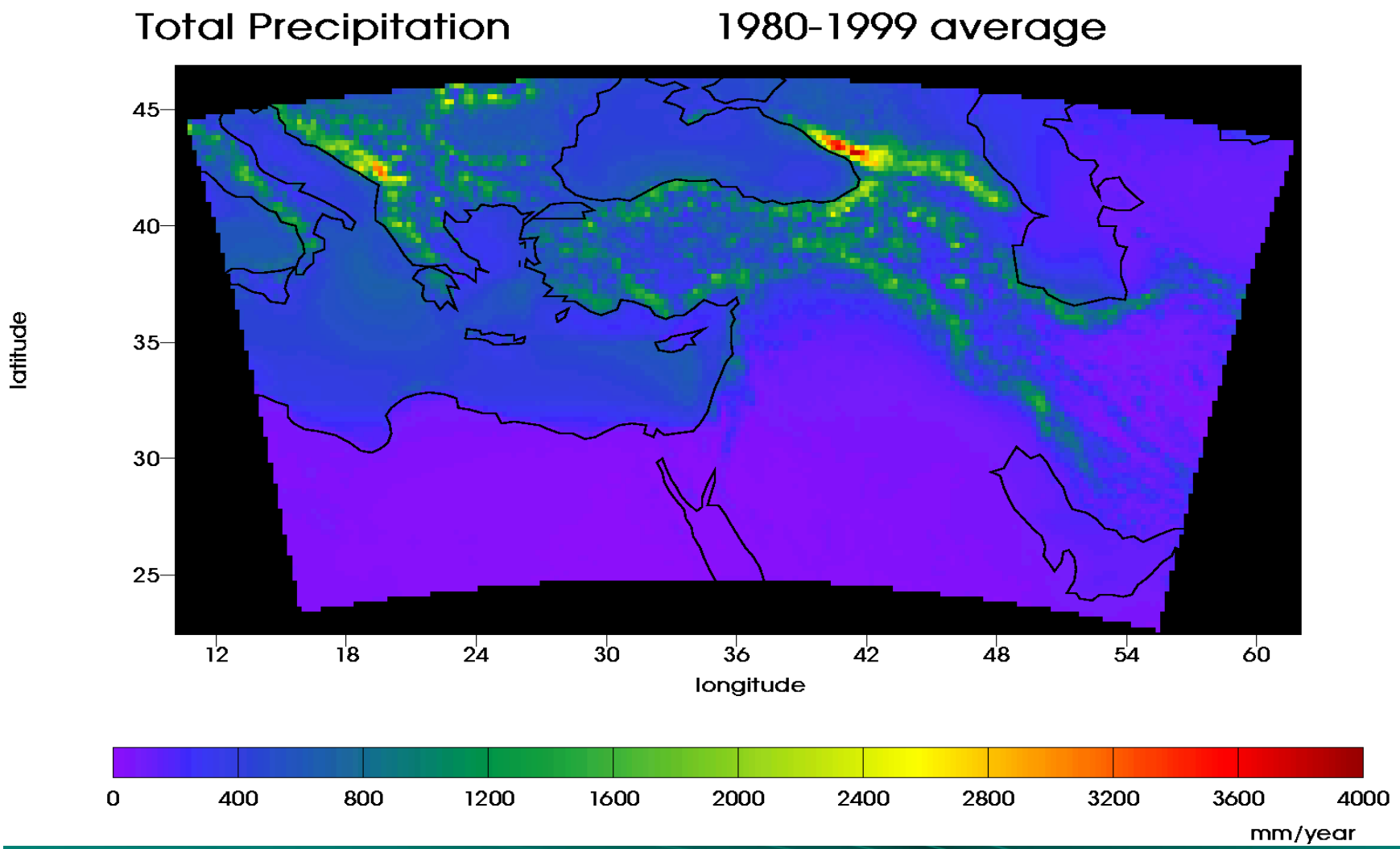


*Adjusted for -1ºC bias

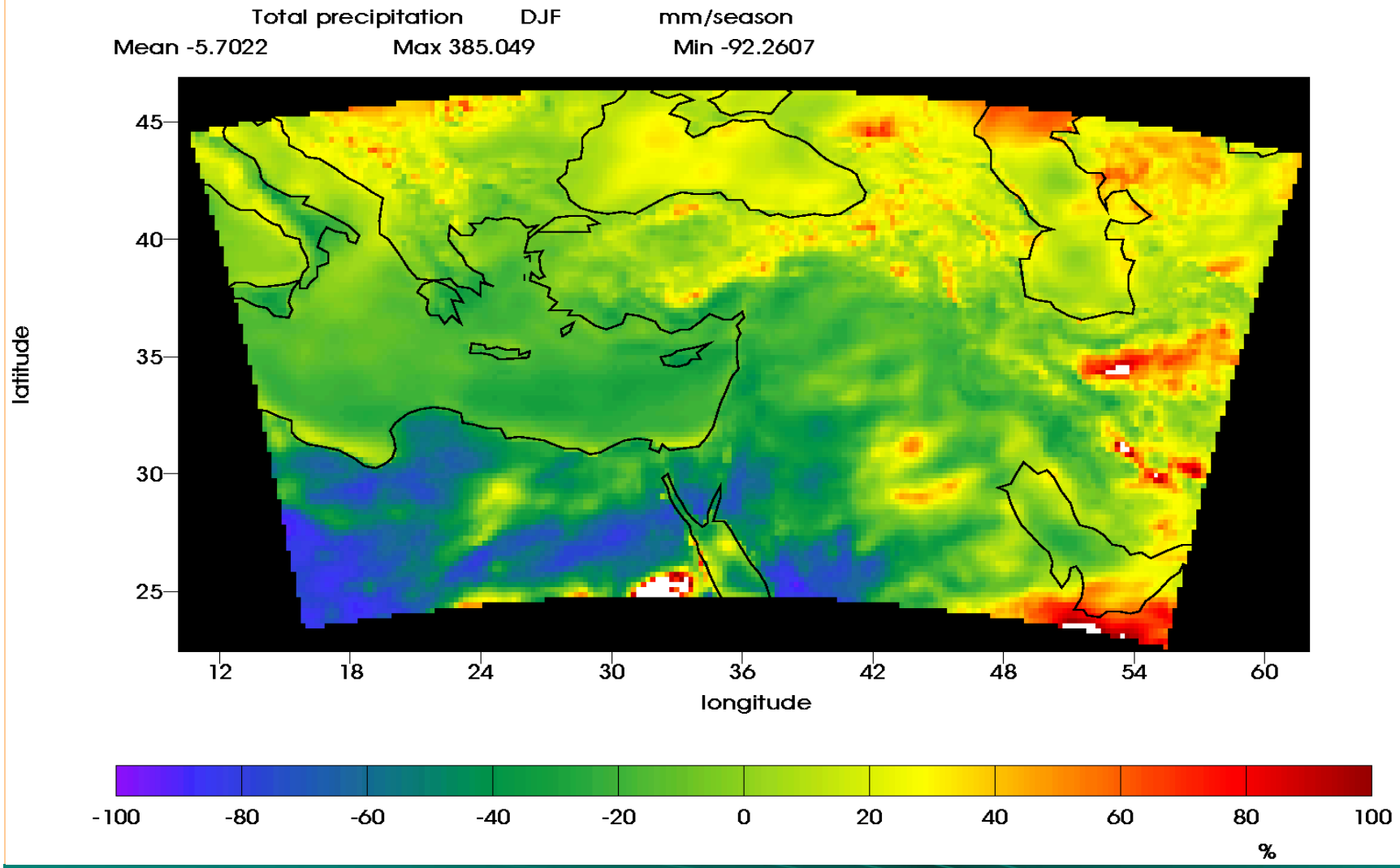
Annual Temperature Nicosia



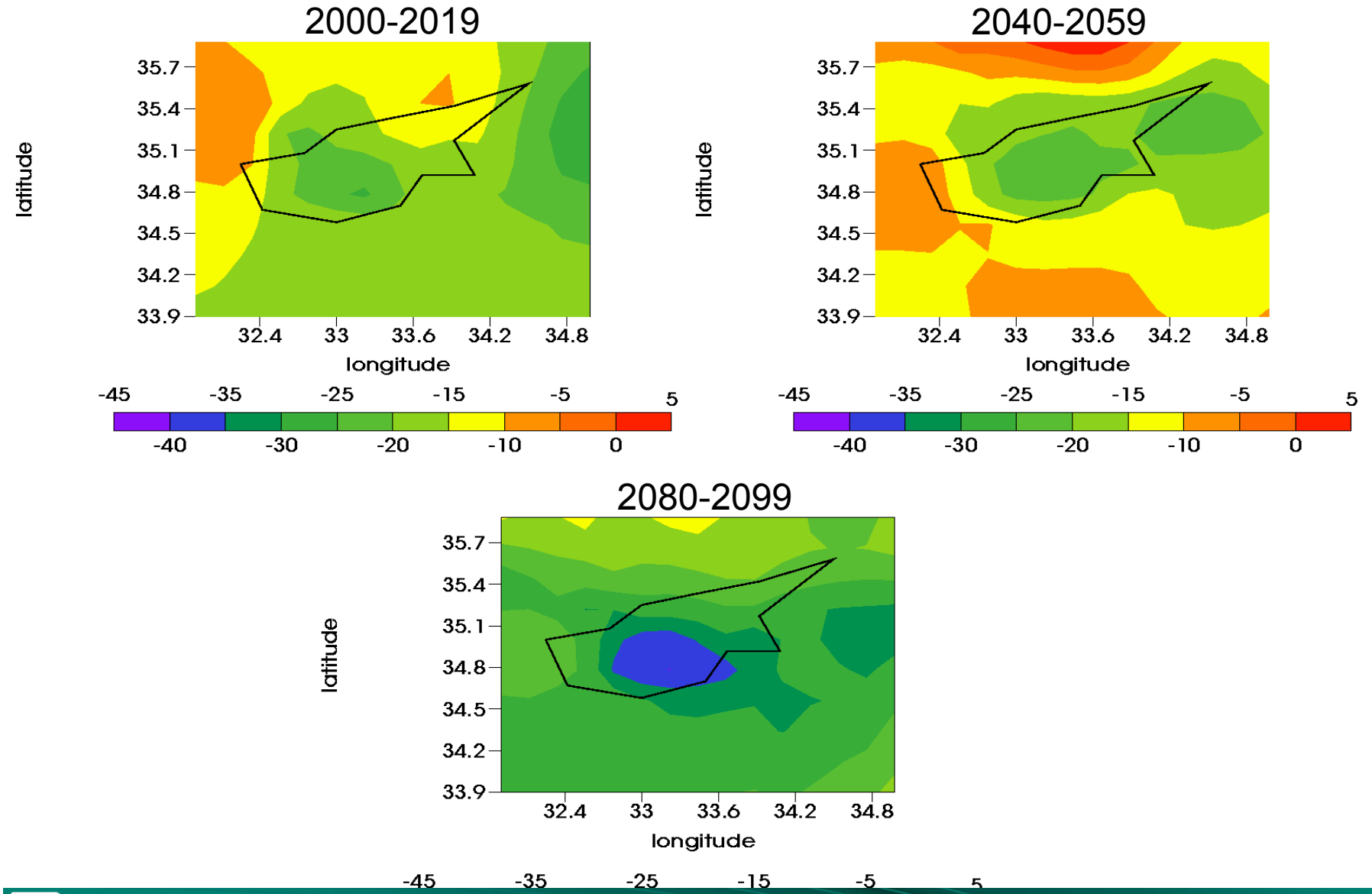
PRECIS Precip 1980-1999



ΔPrcp 2080-2099



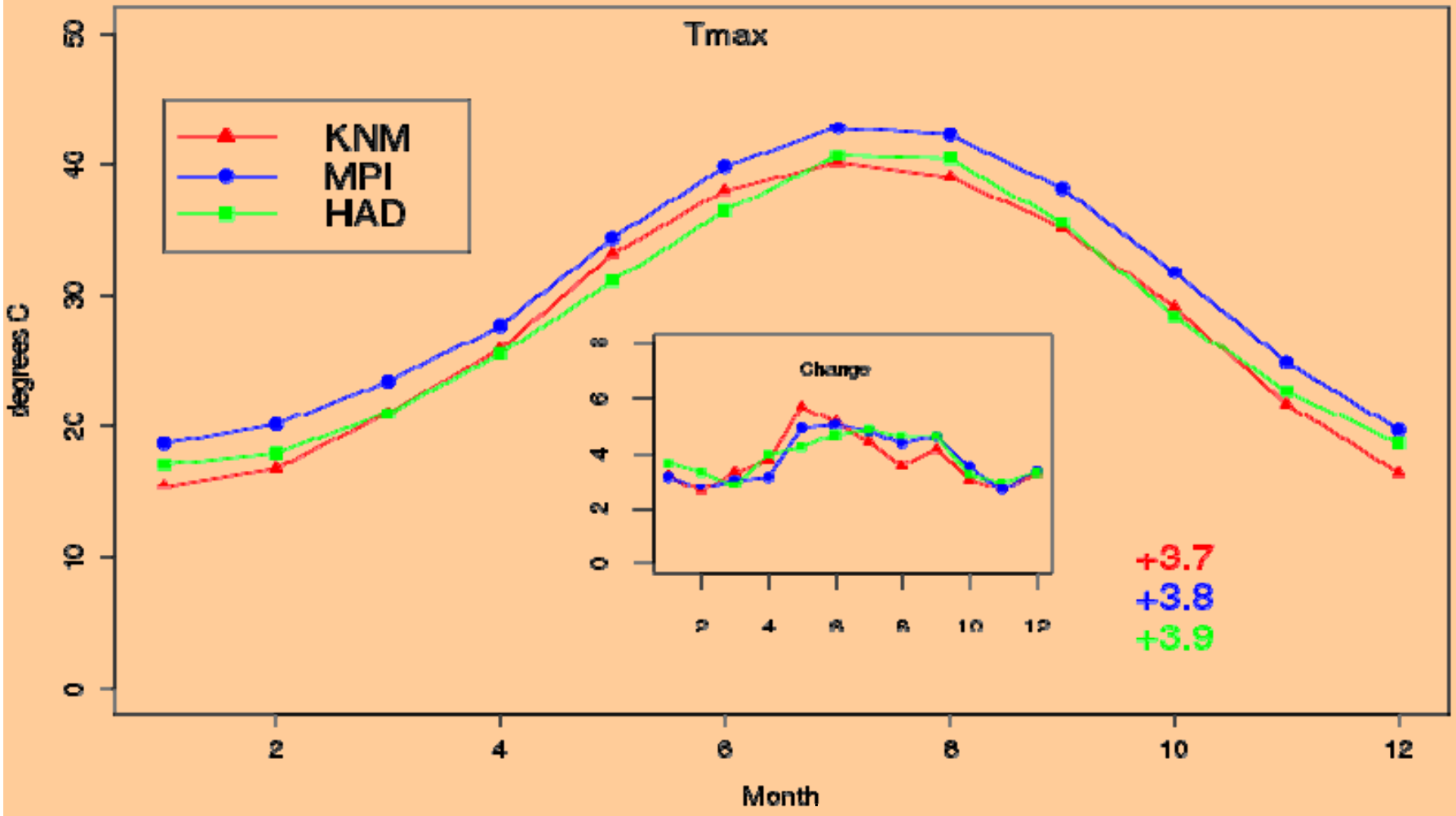
Cyprus Δprcp % from 1980-1999 DJF



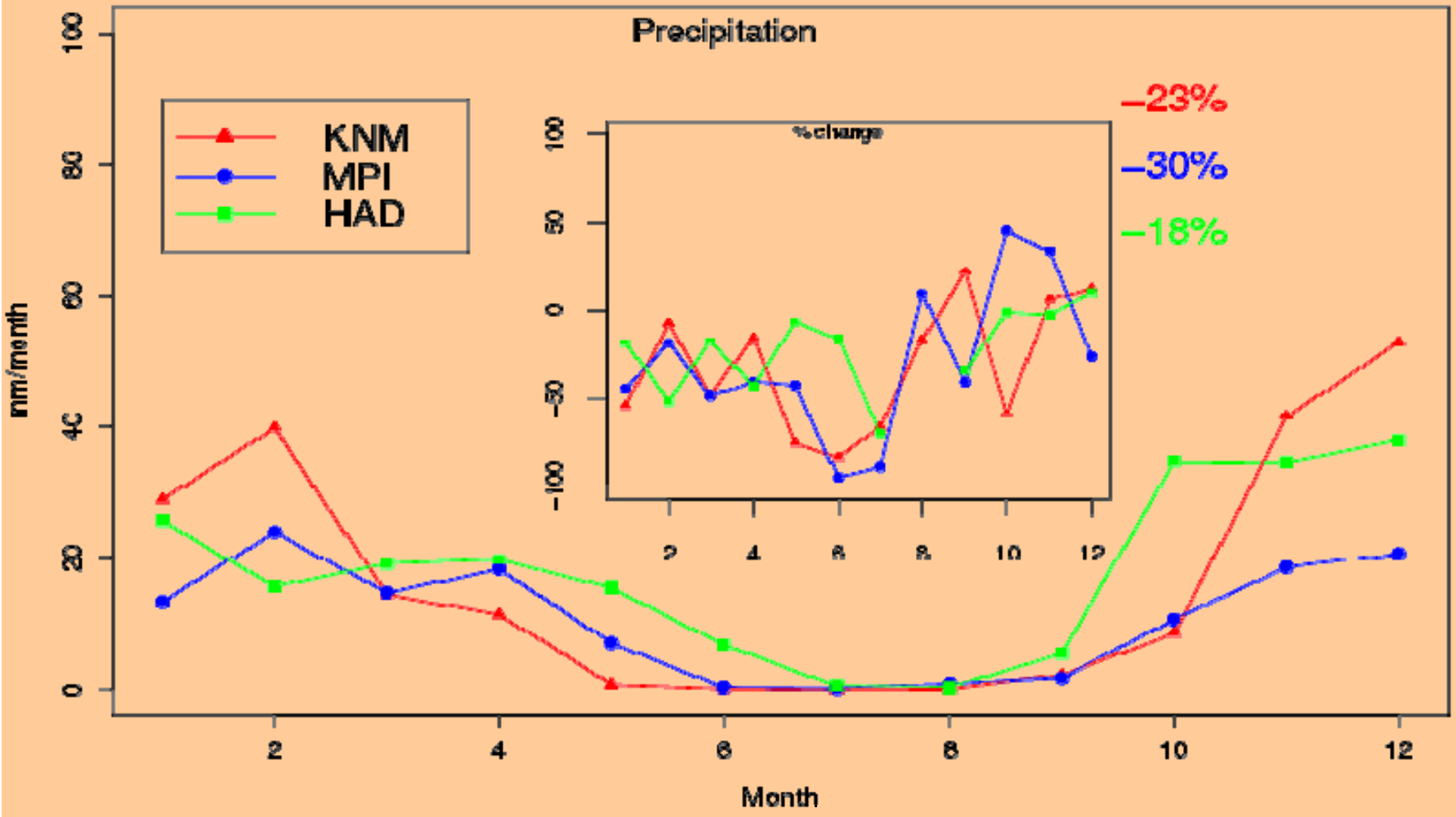
ENSEMBLES results for Cyprus

- National Observatory of Athens (Giannakopoulos, Zerefos)
- KNMI Netherlands, MPI Germany, Hadley Centre UK
- 6 locations in Cyprus
- Tmax, Tmin, Precip
- 1961-1990, 2071-2100
- Changes in mean climate, extremes

Mean climate: Nicosia 2071-2100



Mean climate: Nicosia 2071-2100



Indices of extremes: definition

Threshold:

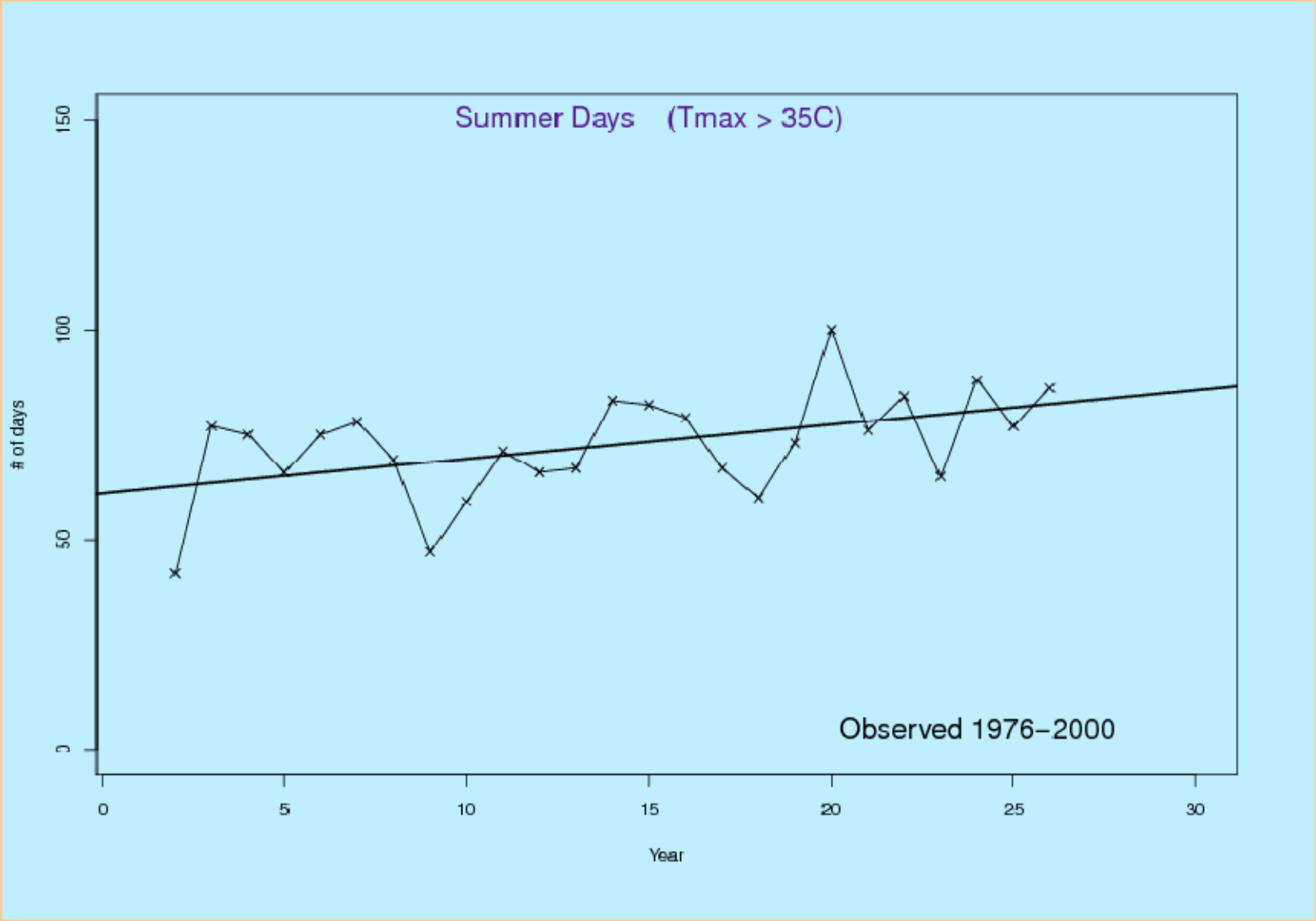
Summer Days (SU35):
days with Tmax > 35^{o}C

Tropical Nights (TR25):
days with Tmin > 25^{o}C

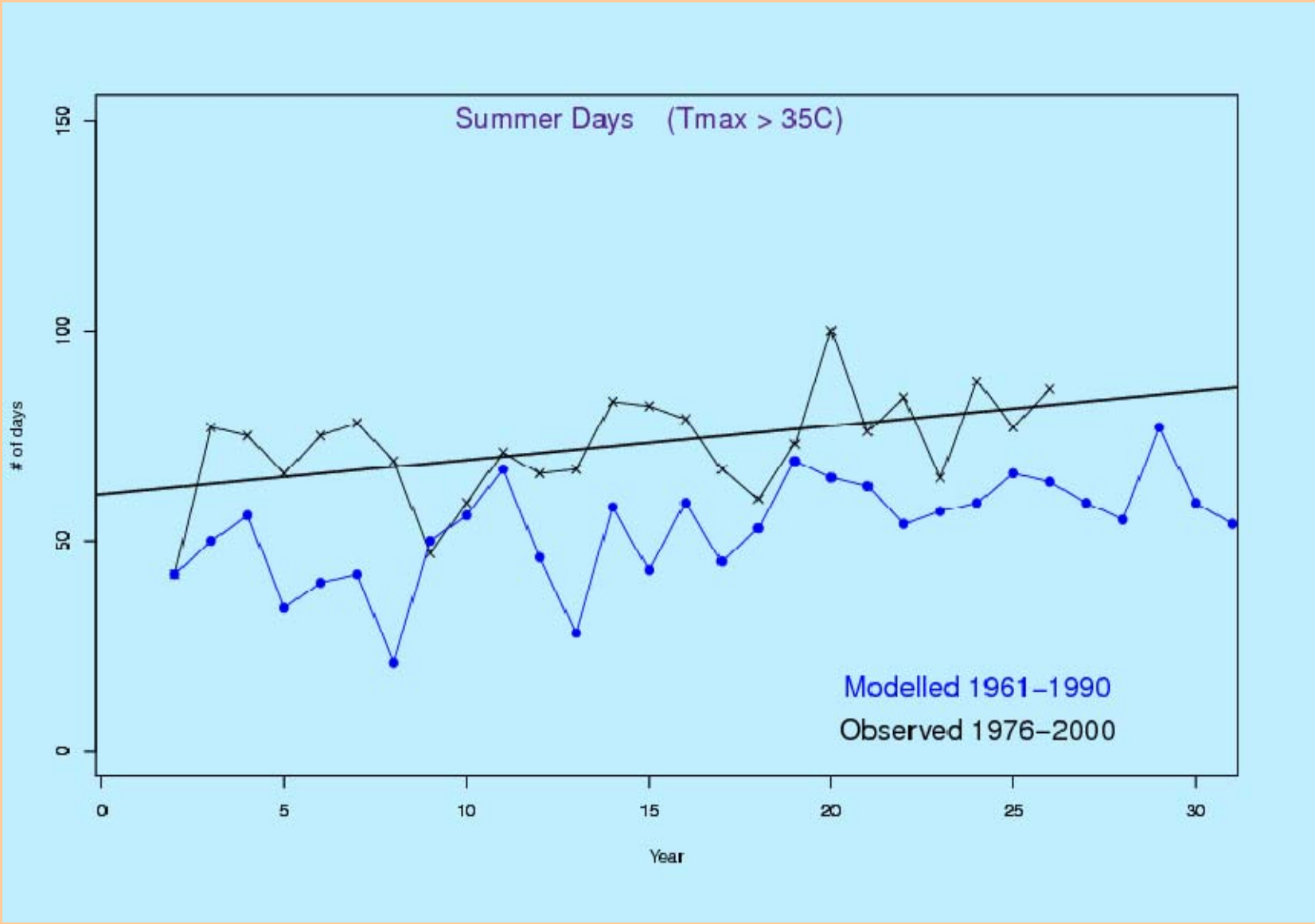
Duration:

Consecutive Dry Days (CDD):
consecutive days with Precipitation < 1mm

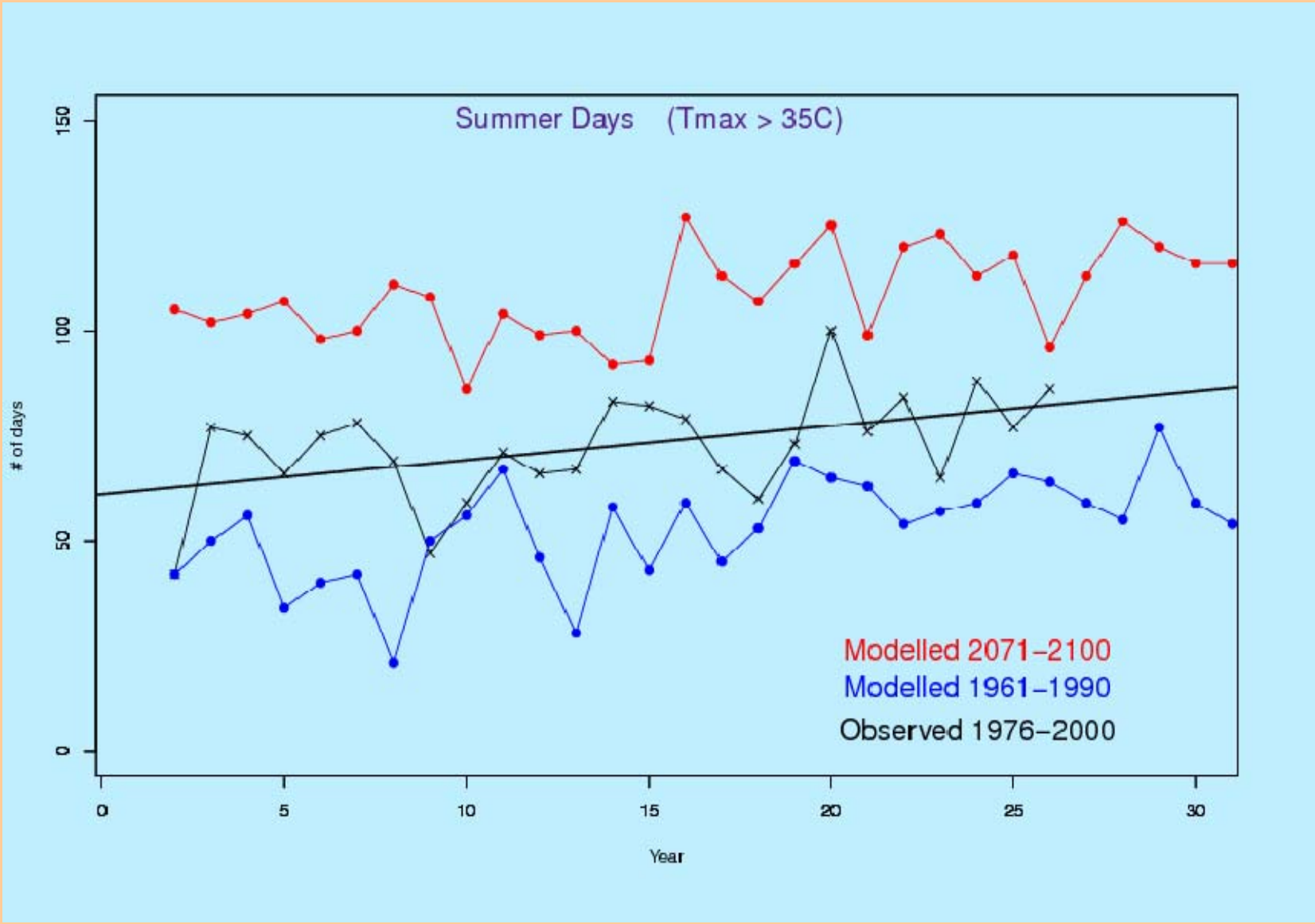
Extremes Nicosia



Extremes Nicosia



Extremes Nicosia



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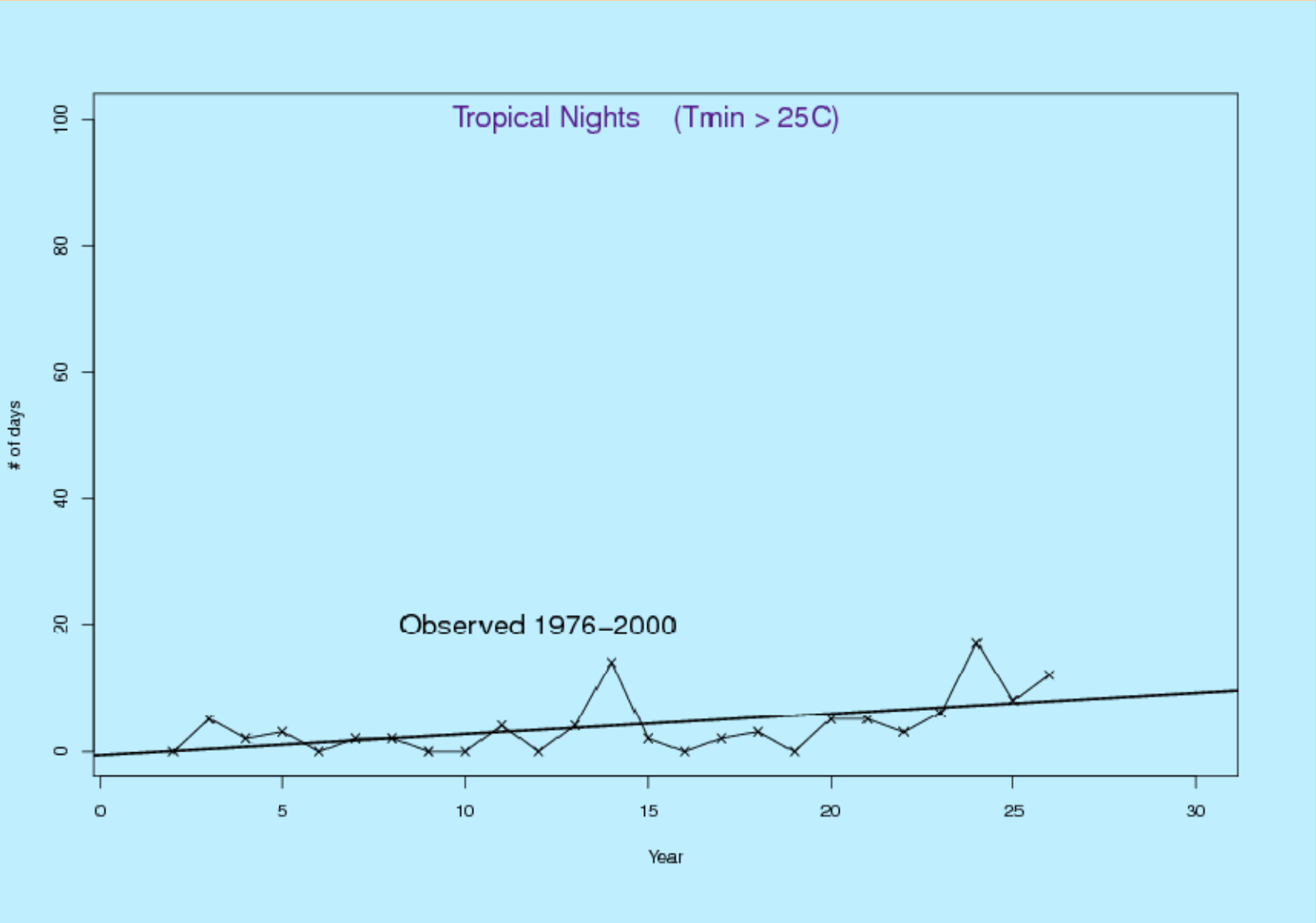

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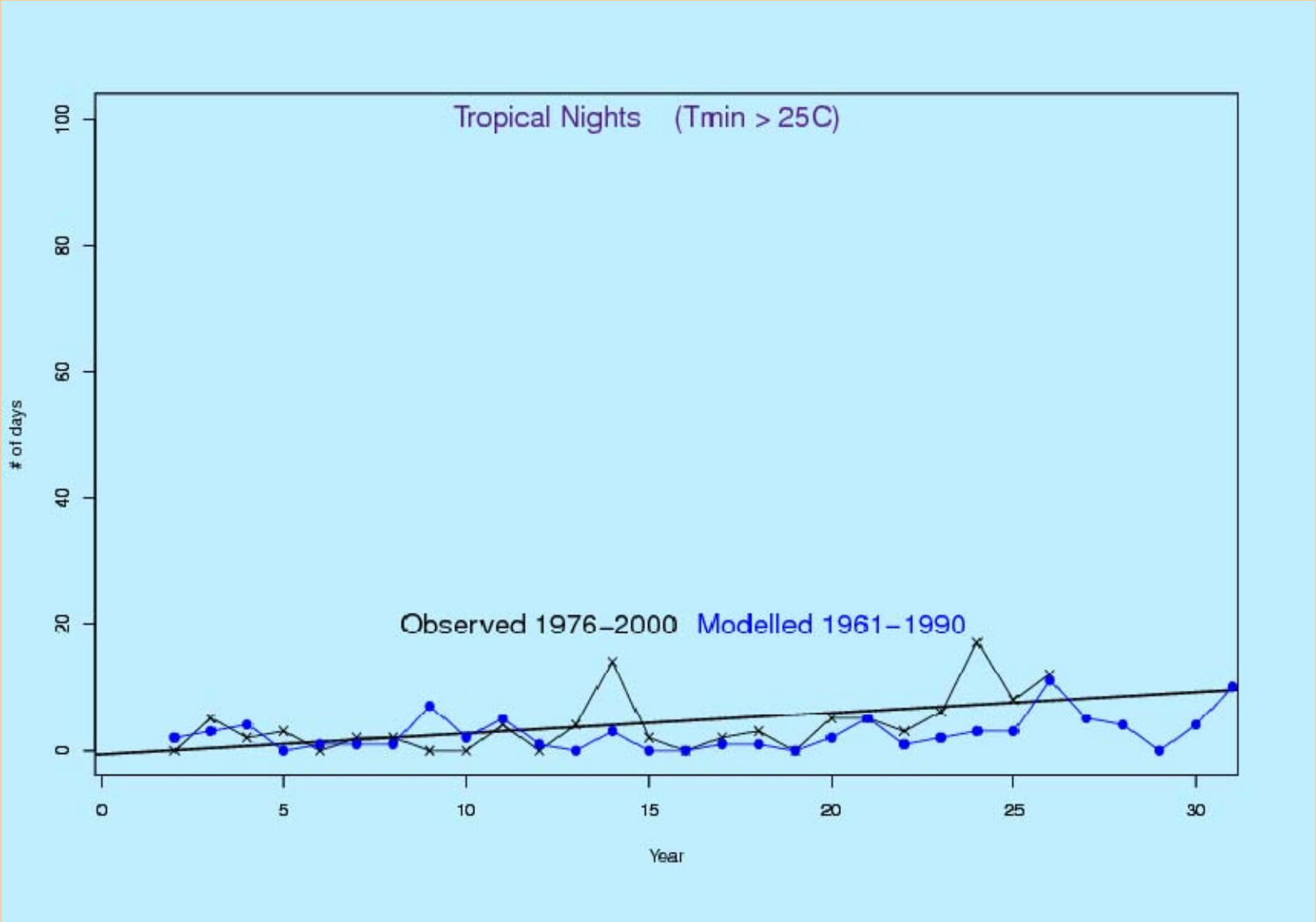

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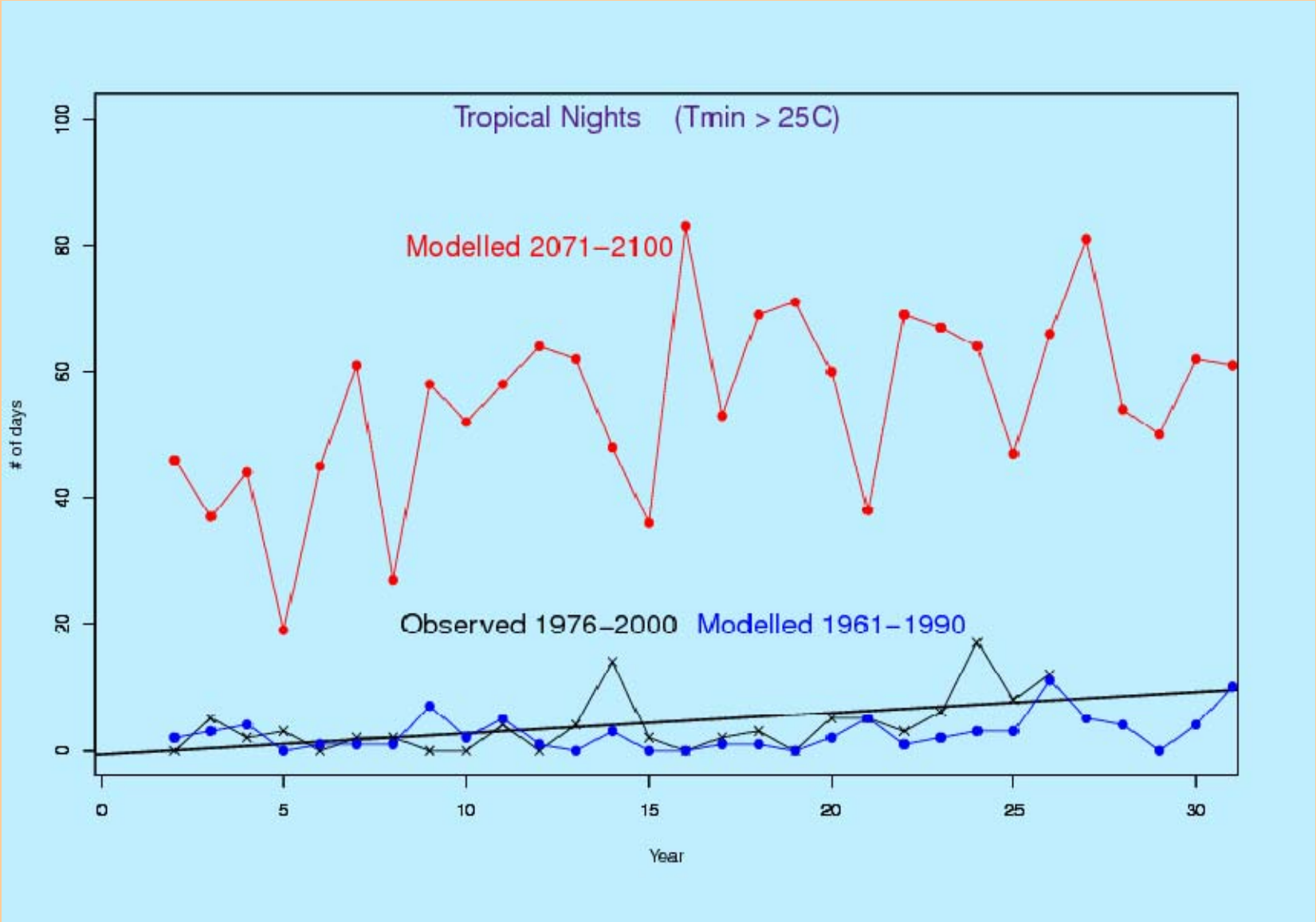
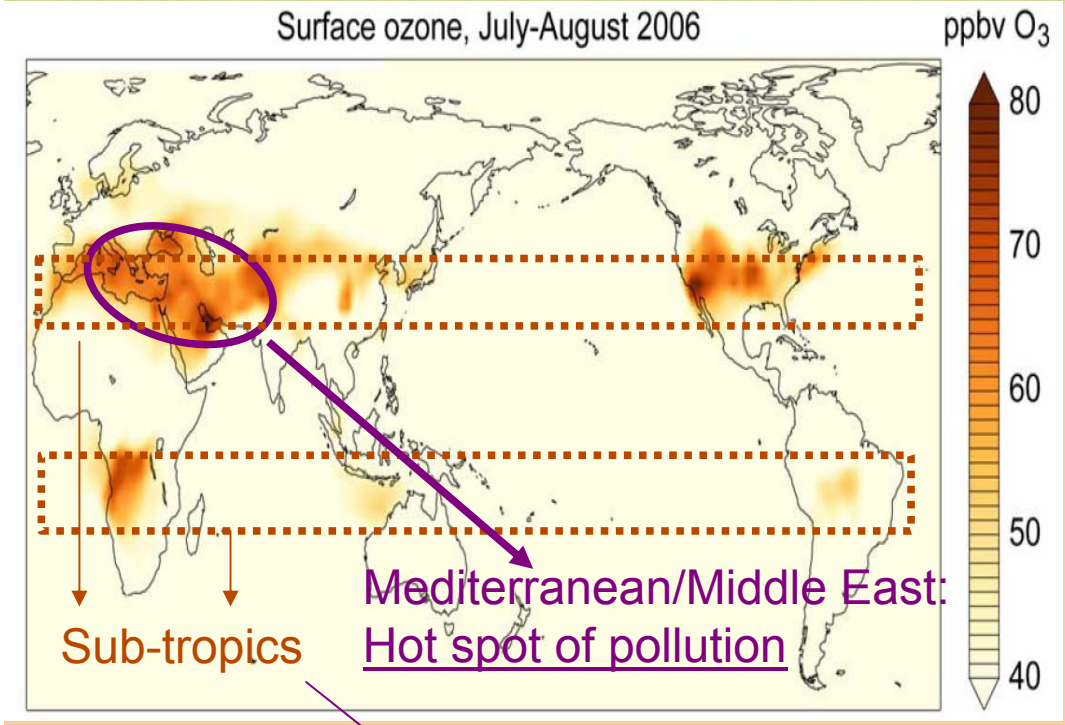


Indices of extremes Nicosia

Index	Name	UNITS	MSC 1976-200	RCM 1961-2000	RCM 2071-2100	ΔRCM
SU35	Summer days	Days	72±5	61	121	**60**
TR25	Tropical nights	Days	4±2	14	72	**58**
TXx	Max Tmax	°C	42±0	42	47	**5**
TNx	Max Tmin	°C	26±1	27	32	**5**
TXn	Min Tmax	°C	9±1	8	11	**3**
TNn	Min Tmin	°C	0±1	-1	3	**3**
DTR	Diurnal temperature range	°C	13±0	12	12	**0**
CDD	Consecutive dry days	Days	119±13	133	157	**24**
CWD	Consecutive wet days	Days	5±0	5	4	**-1**
R10	Number of heavy precipitation days	Days	8±1	5	4	**-1**
R20	Number of very heavy precipitation days	Days	2±1	1	1	**0**
RX1	Max 1-day precipitation amount	Mm	42±7	20	29	**9**
RX5	Max 5-day precipitation amount	Mm	58±8	45	47	**1**
SDI	Simple daily intensity index	Mm/day	7±0	5	5	**0**

Air quality and climate change



Ground-level Ozone

EU health protection limit = 57 ppbv

Permitted exceedances:
25 days averaged over 3 years

Summer average > 60 ppbv

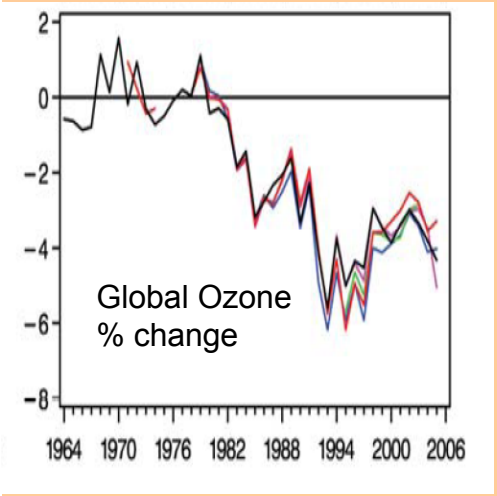
EMAC model, Lelieveld et al., *Atm. Chem. Phys.*, 2009

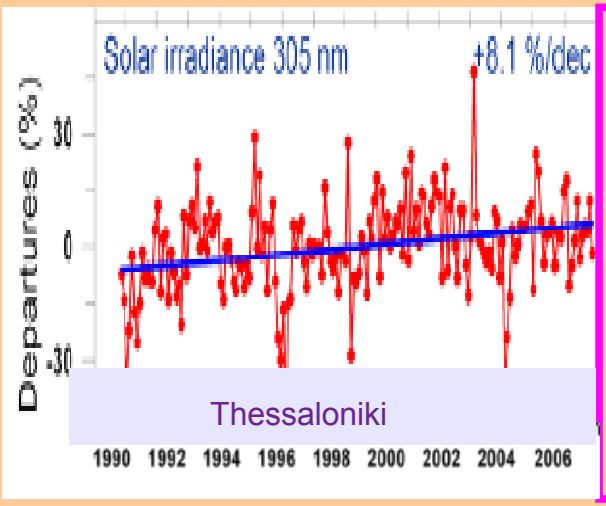
Atmospheric stability, dryness =>

lack of pollutant removal by convective mixing and precipitation

These dry and stagnant conditions are likely to increase under climate change that could deteriorate further the regional air quality

UV radiation and climate change





Stratospheric Ozone Depletion:

- caused by human activities
- enhanced UV radiation
- Climate change affects ozone through:
- stratospheric circulation
- stratospheric temperatures

Climate change can amplify several damaging effects of solar UV-B radiation on human health (Andrady et al., Photochem. Photobiol. Sci., 8, 2009)

- For the same UV dose, each 1°C increase in temperature would result in estimated increases in the incidences of certain skin cancers of 3%-6%,

- High temperatures and humidity, as experienced in the tropics, may increase the deleterious effects of UV-B radiation on human health, including suppression of immunity to infectious diseases and skin cancers

Epilogue

If concentrations of green-house gases continue to rise in the current rates, then by the end of this century global temperature will reach levels much higher than the ones human civilisation has been accustomed to in the last millennia

For Cyprus especially, regional climate models project:

Conclusions

- Average temperature will increase by 4^{o}C
- Maximum temperatures will rise more in the summer than in the winter
- Summer days and tropical nights will increase by 2 months
- Precipitation will decrease by 30-40%
- Dry periods will increase by 1 month
- Air quality could deteriorate

Acknowledgements

➔ Cyprus data: Meteorological Service Cyprus

➔RCM output/extraction: C. Giannakopoulos, NOA, ENSEMBLES EU FP6

➔ PRECIS software/support: PRECIS Team, Hadley Centre, UK Met. Office

➔ RclimDex: X. Zhang, Environment Canada, CCl/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices

➔CDAT: PCMDI/LLNL, US Dept. of Energy

Impacts of Mediterranean Climate Change on Human Health

Workshop

19-21 October 2009

Paphos Gardens Hotel, Cyprus

The Cyprus Institute

European Science Foundation
Setting Science Agendas for Europe

EEWRC

Motivation

- **The Mediterranean Basin is experiencing impacts of climate change as its influence on human health**
- **The Mediterranean area has to deal with**
  - growing population pressure
  - vulnerability to impacts of climate change on human security
    - sea level rise
    - water supply and quality
    - drought
    - crop yields
    - direct impacts on human health – heat waves, wildfires, vector-borne diseases, etc.

Main Topics

- Health effects of extreme heat and cold
- Vulnerability to extremes of the hydrologic cycle
- Exposure to infectious diseases
- Changes in aeroallergen and allergic airway diseases
- Air and water quality changes
- Climate change and the built environment
- Compounding effects of economic discrepancy and hardship on the health of Mediterranean populations in a changing climate

Thank you

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The Cyprus Institute

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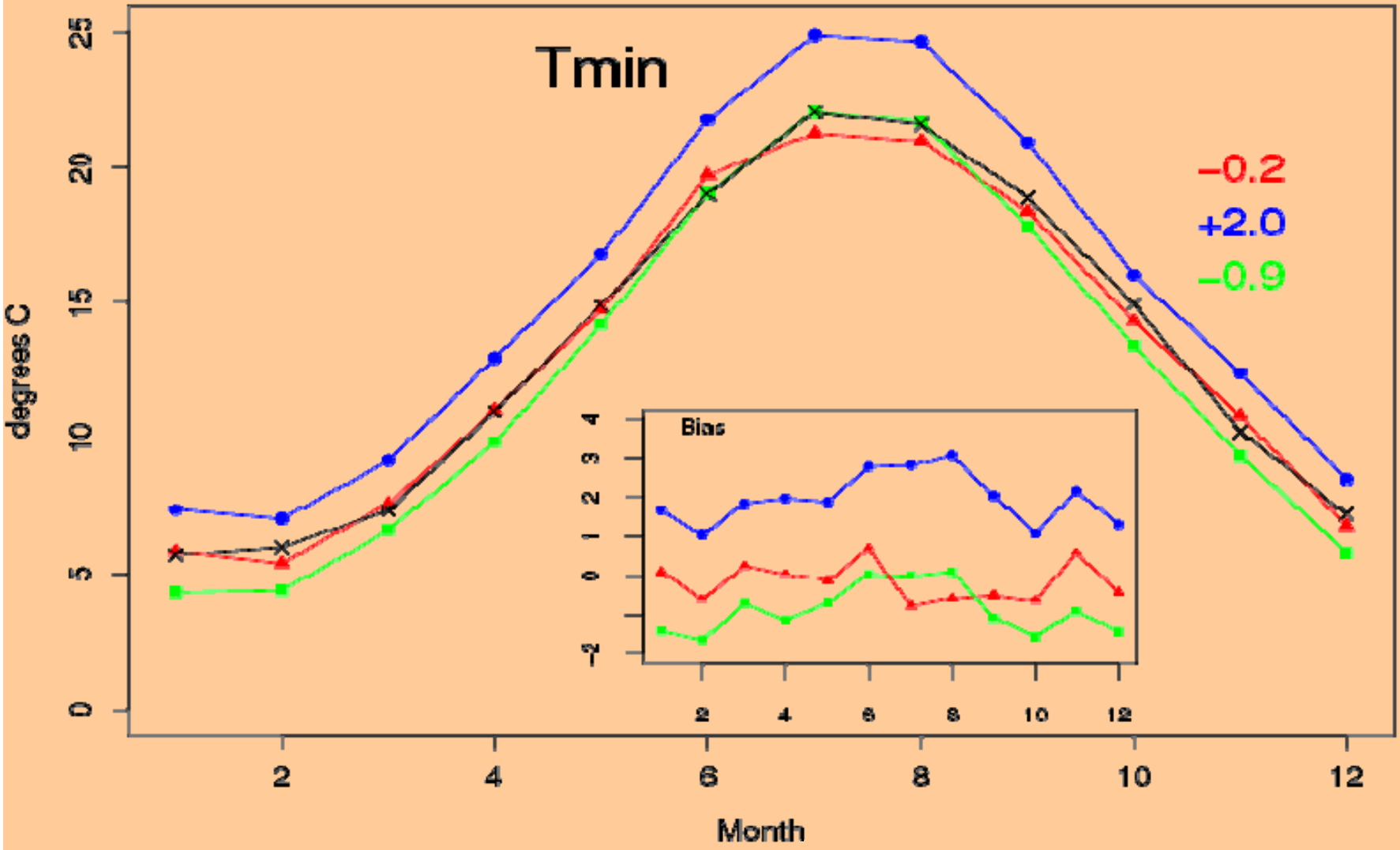
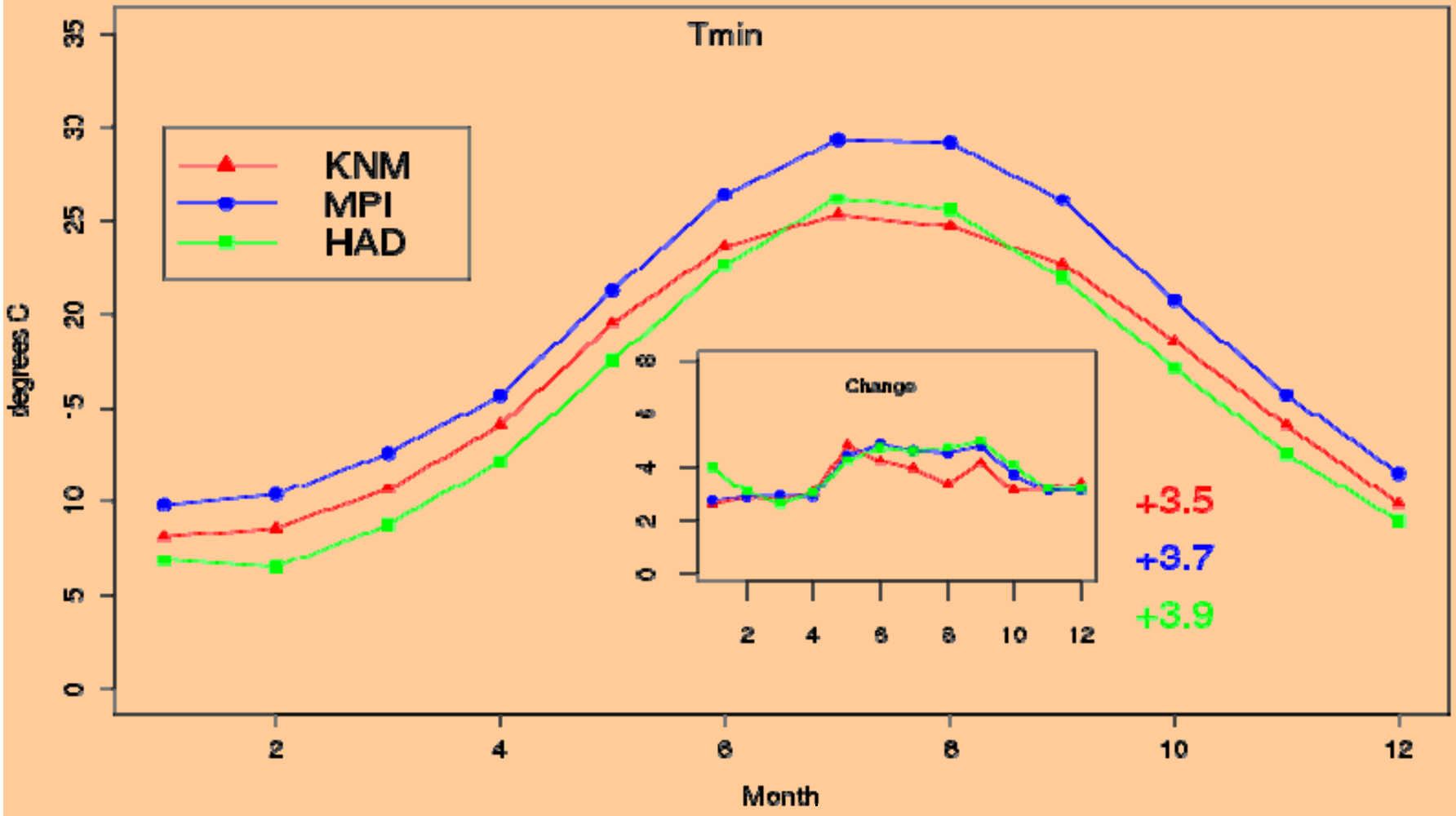
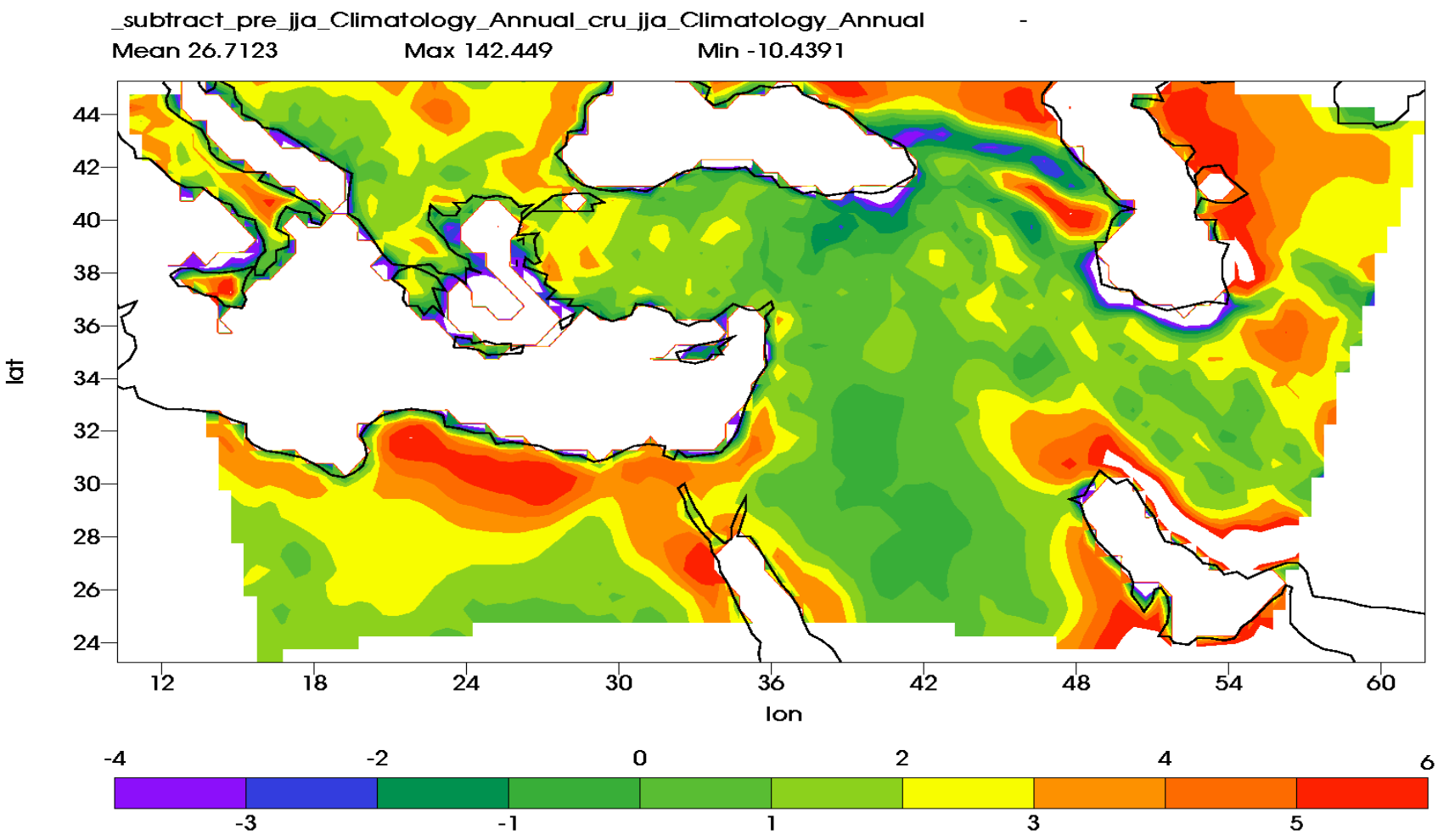
Mean climate: Nicosia 1976-1990



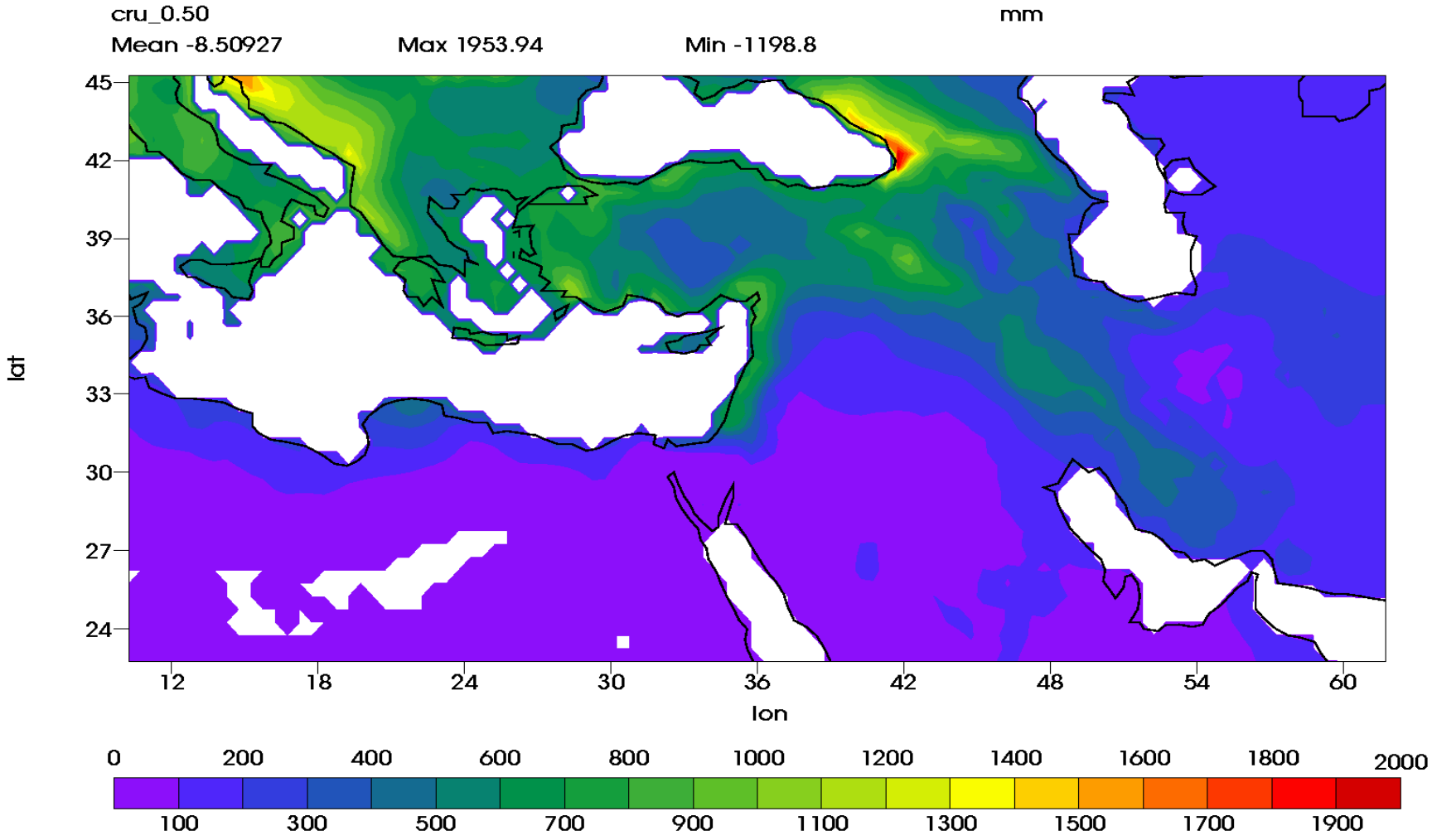
Mean climate: Nicosia 2071-2100



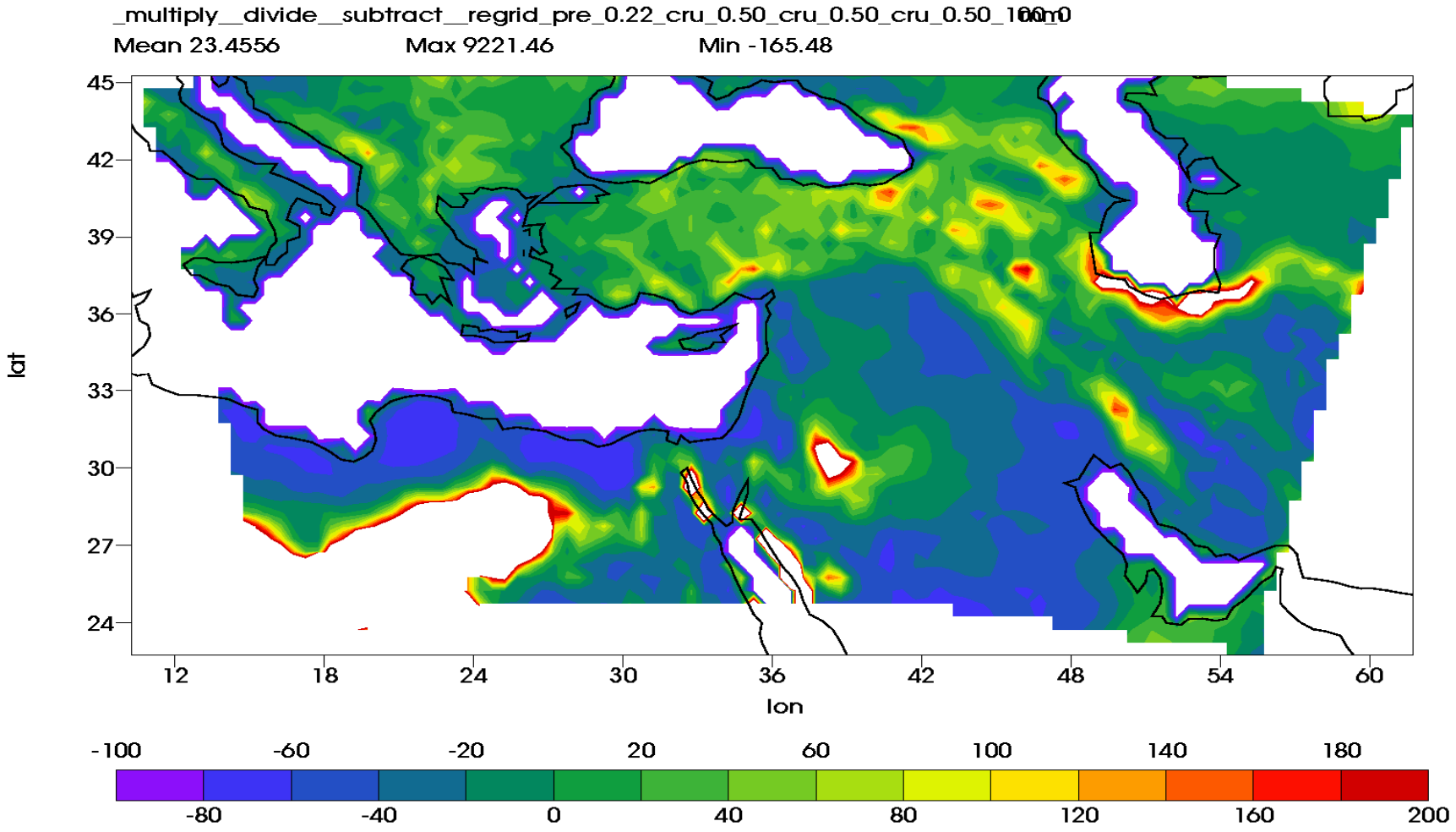
PRECIS – CRU Tmax JJA 1980-1999



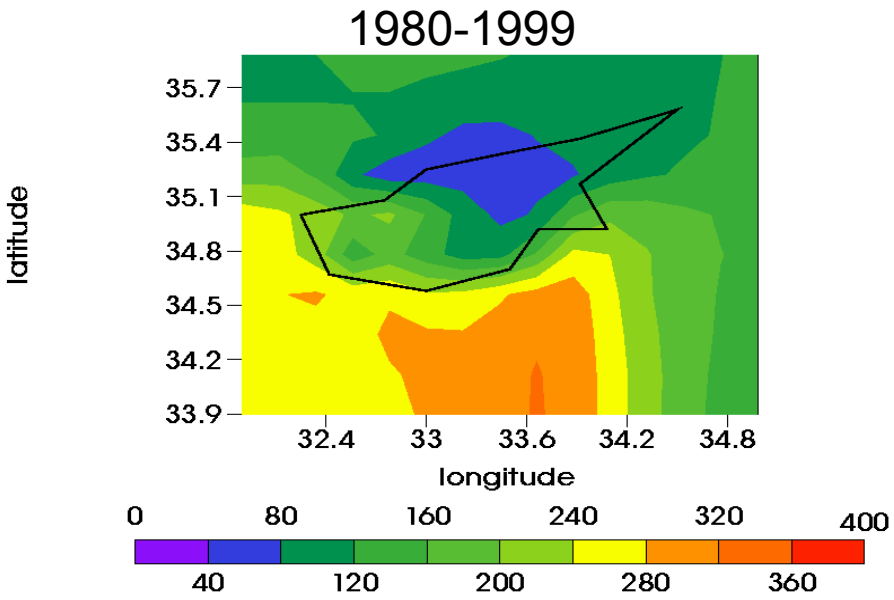
CRU Precip 1980-1999

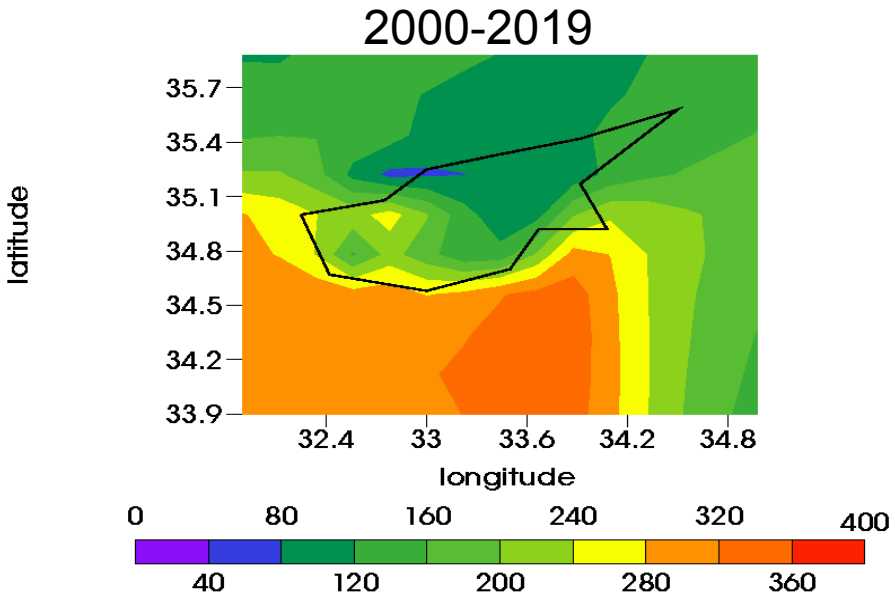


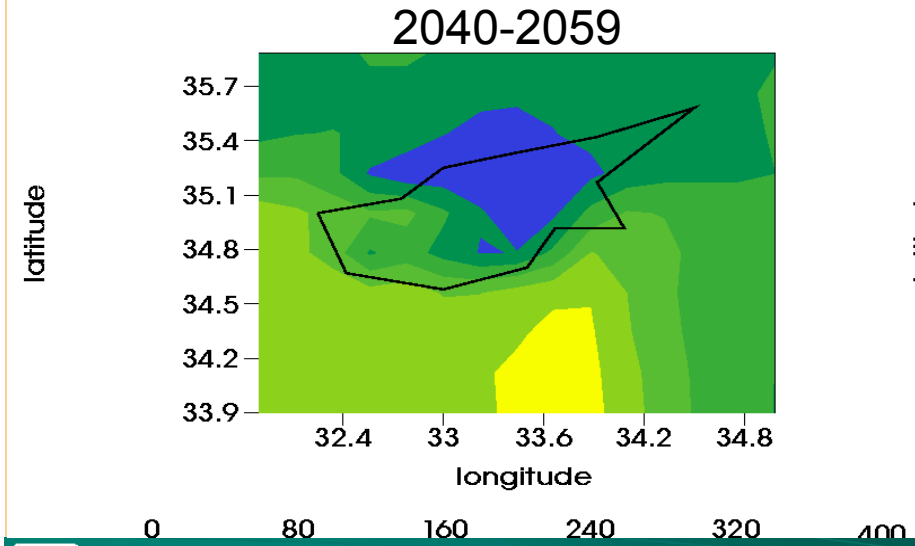
PRECIS vs CRU Precip 1980-1999

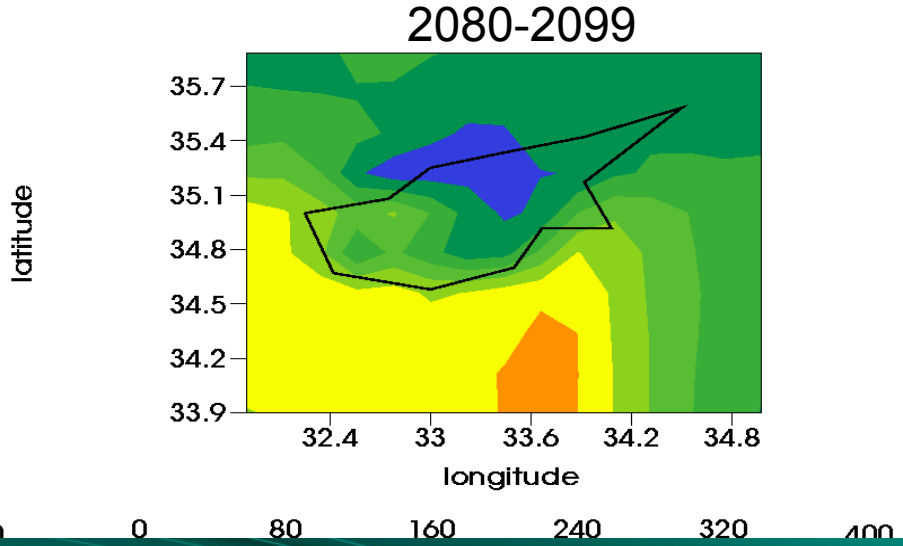


Cyprus Precipitation DJF









PRECIS: RCM model

www.precis.org.uk

Welcome to the PRECIS website!

PRECIS stands for "Providing REgional Climates for Impacts Studies."

Developed at the Hadley Centre at the UK Met Office, PRECIS is a regional climate modelling system designed to run on a Linux based PC.

PRECIS can be easily applied to any area of the globe to generate detailed climate change projections.

PRECIS: RCM model

PRECIS RCM: HadRM3P

Prognostic: P, u,v, T, q

Diagnostic: Precip., Cloud amount, Rad. Fluxes, evaporation rates, etc.

- Horizontal grid: regular Lat-Lon
- Coordinate system: spherical polar (rotated)
- Parametrisations: clouds/precipitation, radiation, aerosols (direct, 1st indirect effects), boundary layer,land surface (MOSES I), gravity wave drag

(Jones et al., 2004)

PRECIS: driving model

"Father" Model: HadCM3Q0

Coupled Ocean-Atmosphere

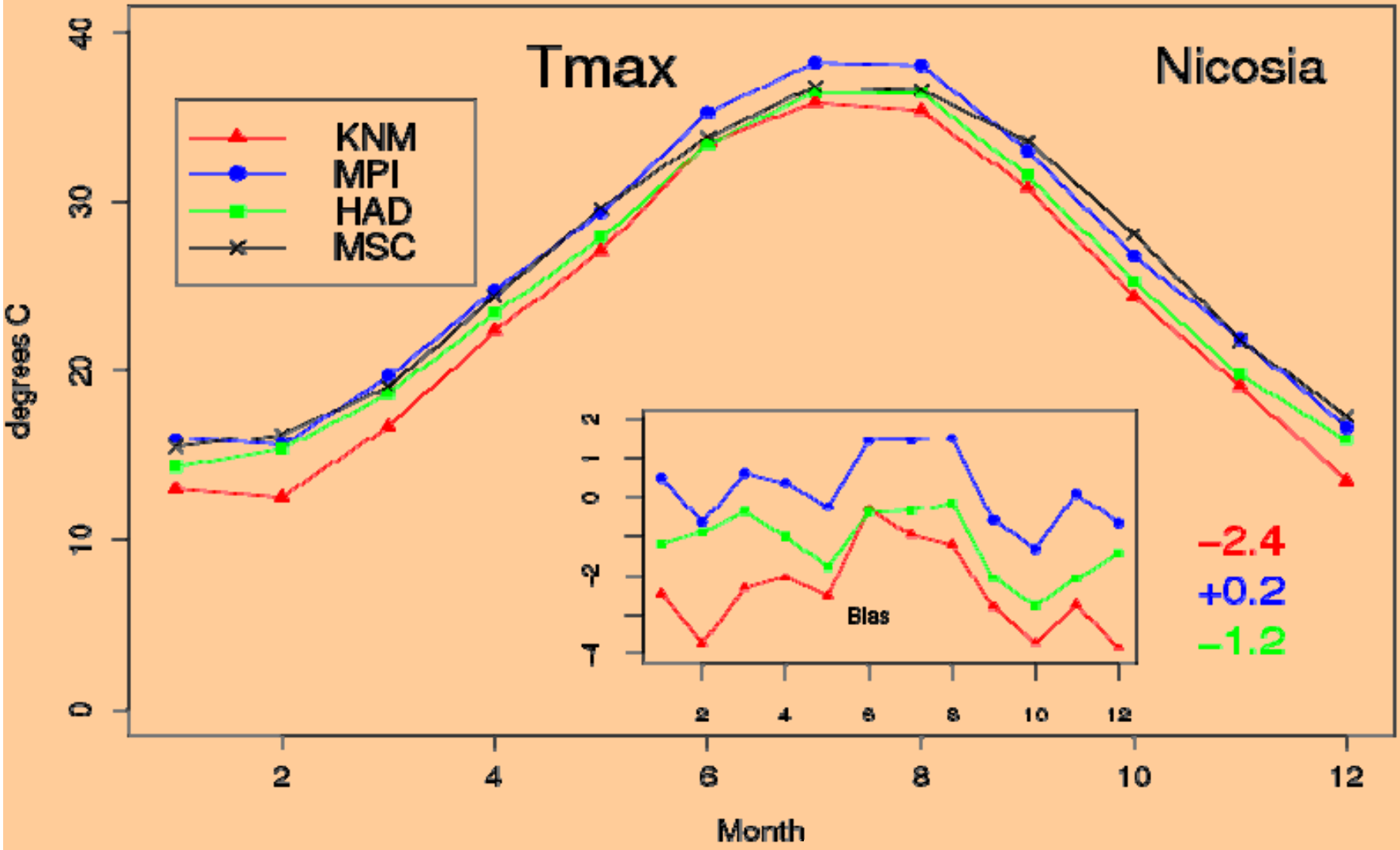
Initial and boundary (every 6h) conditions:

- atmosphere
- sea surface

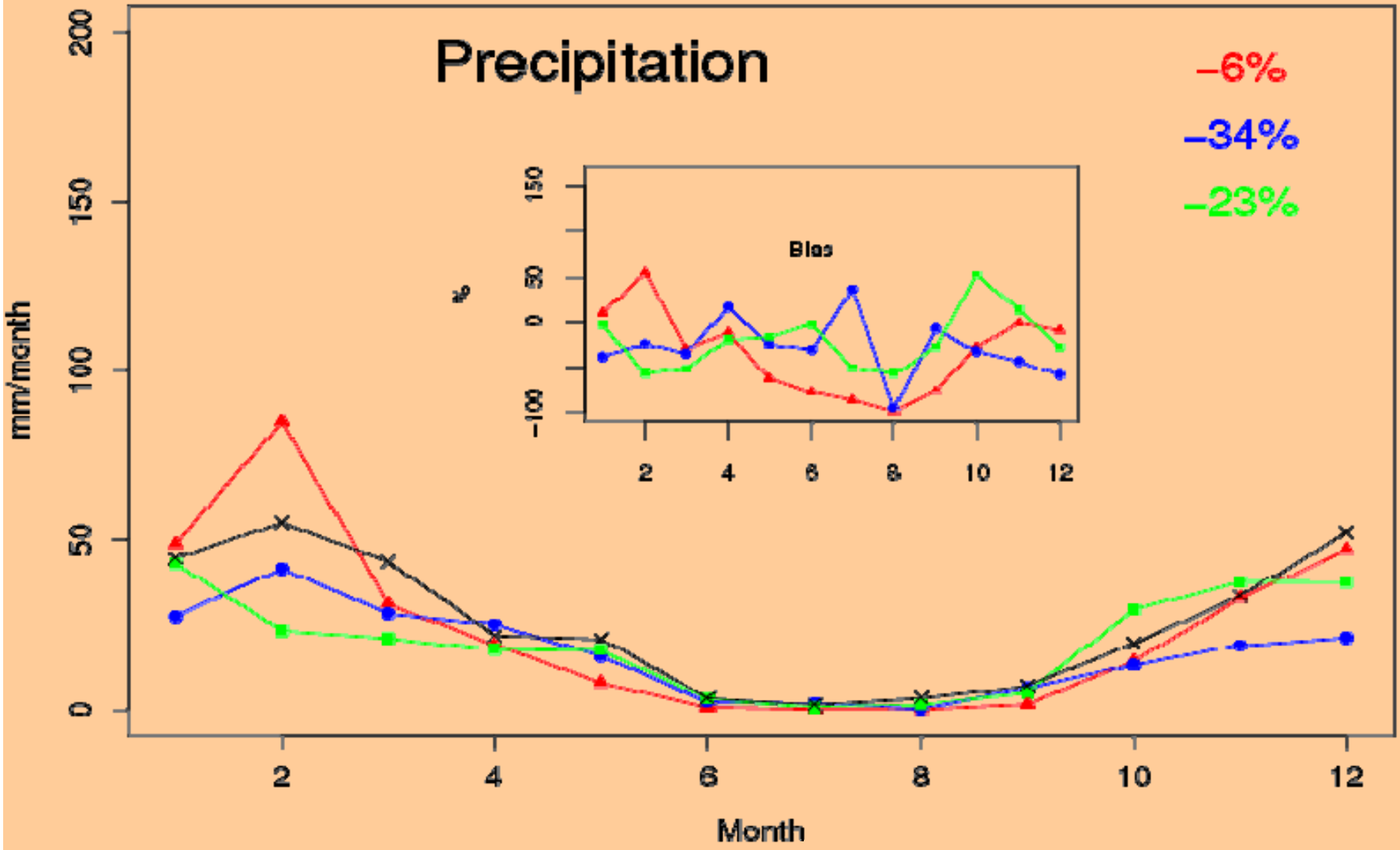
Forcings/sensitivity

- SRES A1B emissions scenario (medium)
- normal climate sensitivity

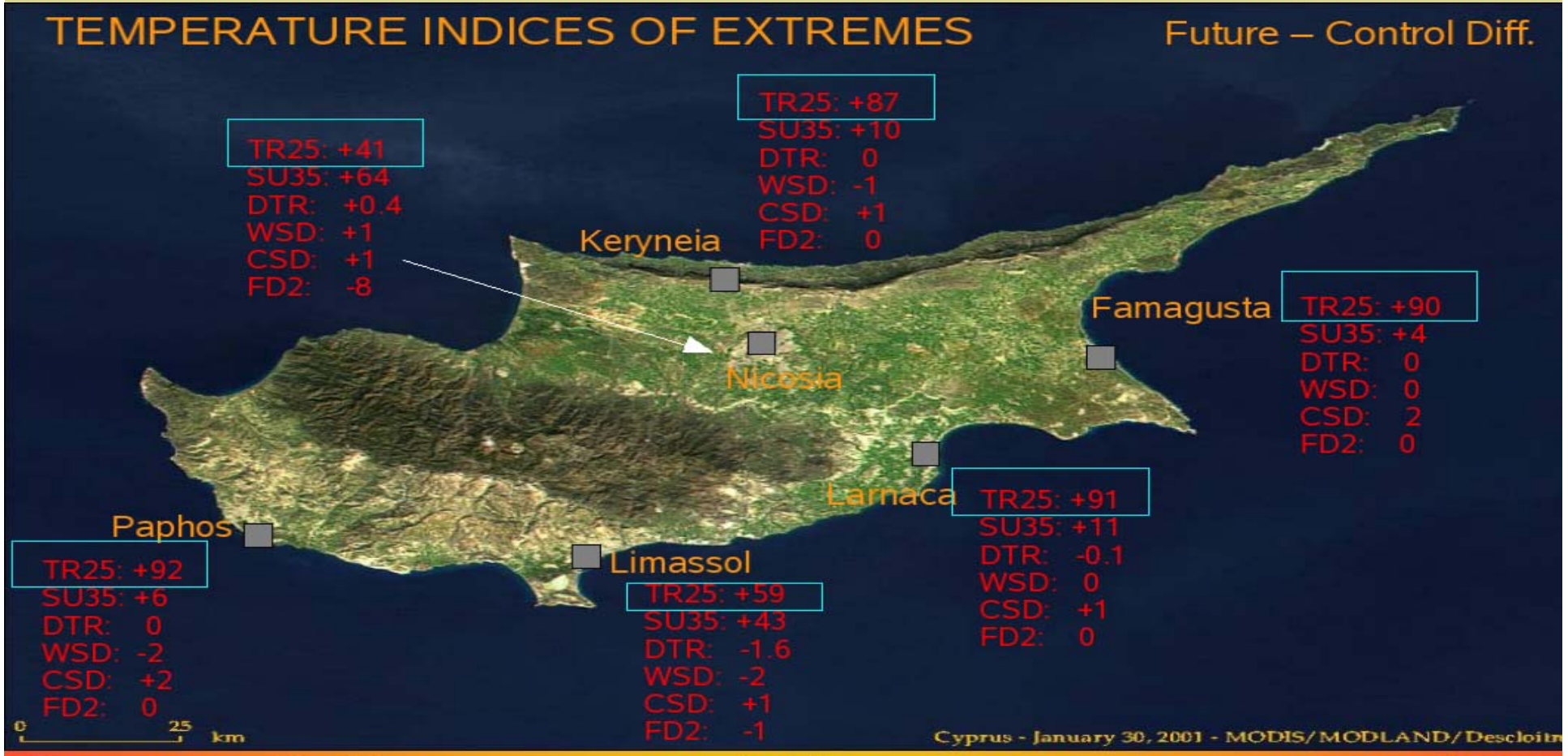
Mean climate: Nicosia 1976-1990



Mean climate: Nicosia 1976-1990

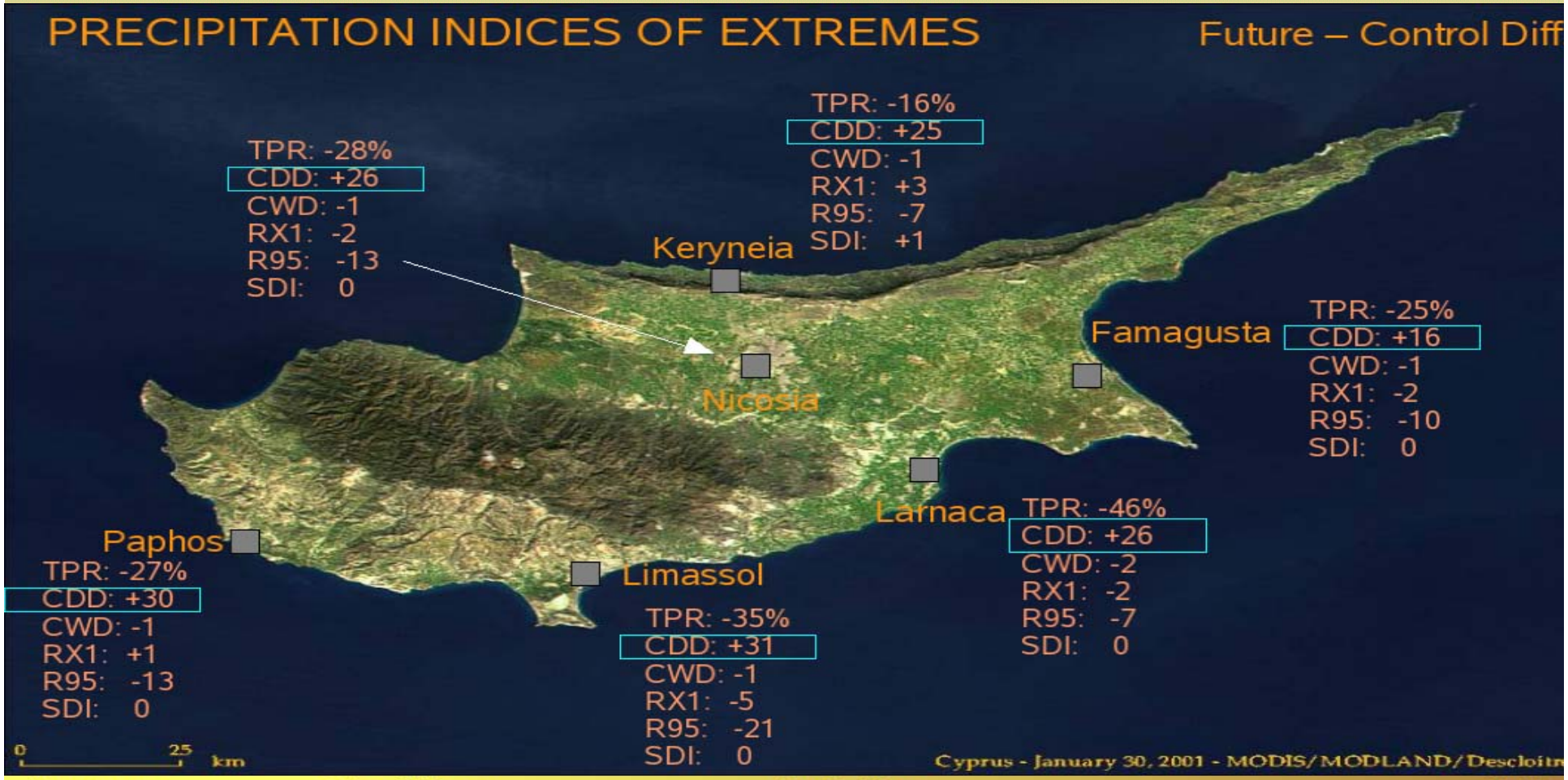


Extremes: Cyprus



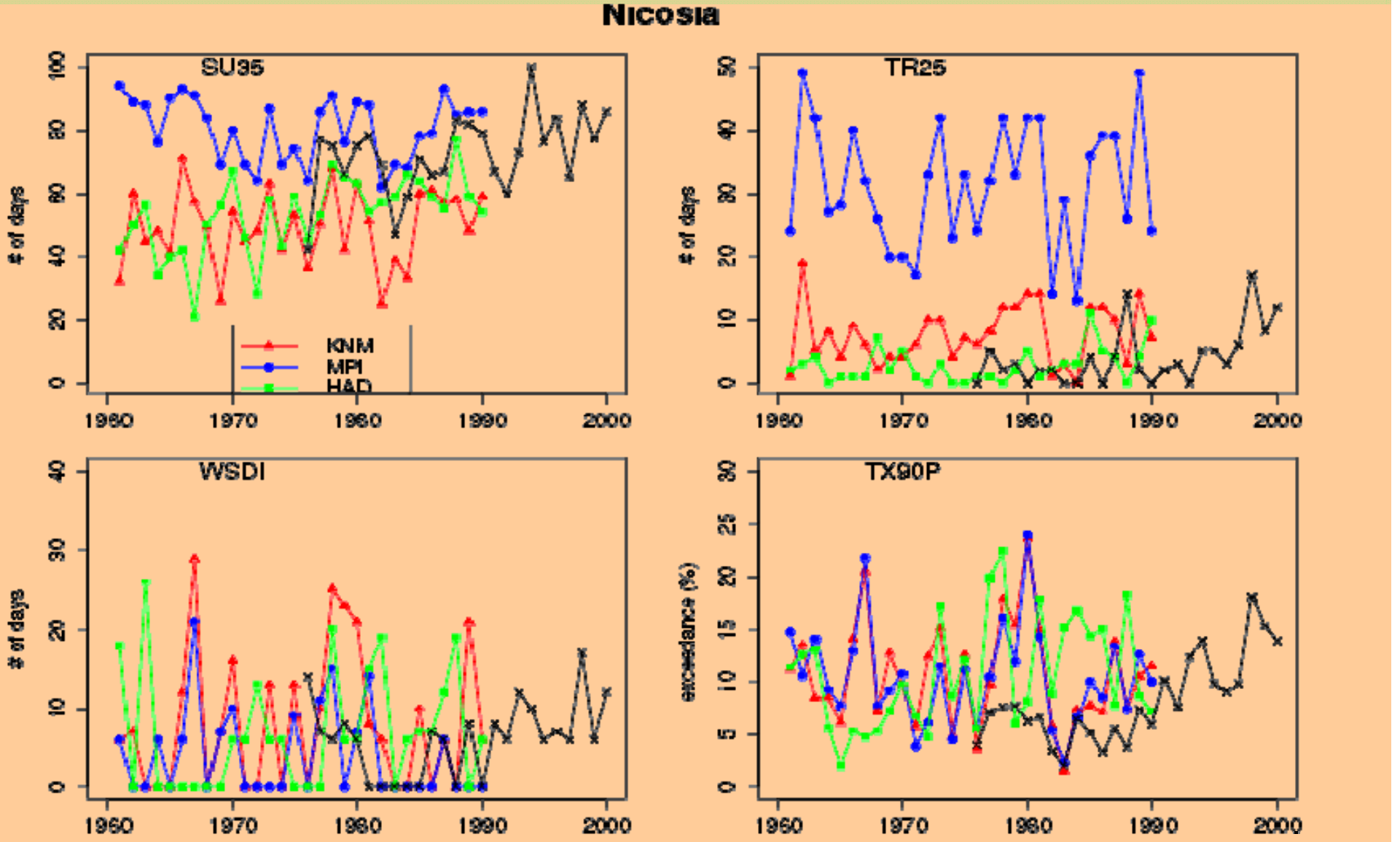
Acronym	Short Name	Definition	Units
TR25:	Tropical nights	= annual count when daily Minimum Temperature (T_N) > 25°C	days
SU35:	Summer days	= annual count when daily Maximum Temperature (T_X) > 35°C	days
DTR:	Diurnal temperature range	= monthly mean difference between T_X and T_N	°C
WSD:	Warm spell duration	= annual count of days with at least 6 consecutive days when T_X>90th percentile	days
CSD:	Cold spell duration	= annual count of days with at least 6 consecutive days when T_N<10th percentile	days
FD2:	Near-frost days	= annual count when T_N < 2°C	days

Extremes: Cyprus

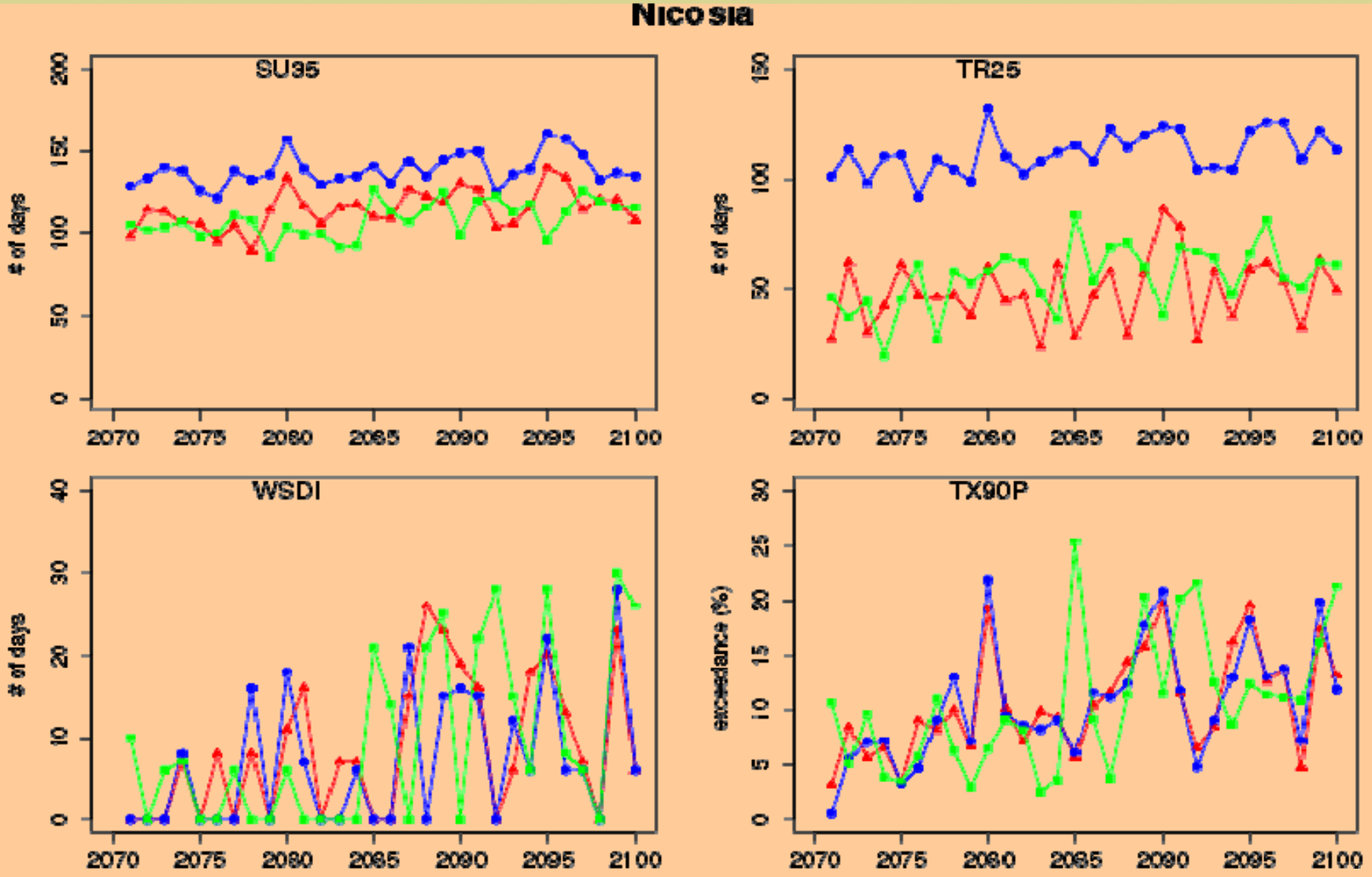


Acronym	Short Name	Definition	Units
TPR:	Annual total wet-day precipitation	= annual total precipitation in wet days (with rainfall ≥ 1mm)	%
CDD:	Consecutive dry days	= maximum number of consecutive days with rainfall < 1mm	days
CWD:	Consecutive wet days	= maximum number of consecutive days with rainfall ≥ 1mm	days
RX1:	Max. 1-day precipitation amount	= monthly maximum precipitation amount	mm
R95:	Very wet days	= annual total precipitation when rainfall > 95th percentile	mm
SDI:	Simple daily intensity	= annual total precipitation divided by the no. of wet days (rainfall ≥ 1mm)	mm/da

Extremes: Nicosia 1960-2000



Extremes: Nicosia 2071-2100



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