Cyprus Climate Change Risk Assessment (CCRA)

“Χαρακτηρίζοντας το μέλλον. Σενάρια κλιματικής αλλαγή

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Λευκωσία, 6 Οκτωβρίου 2016

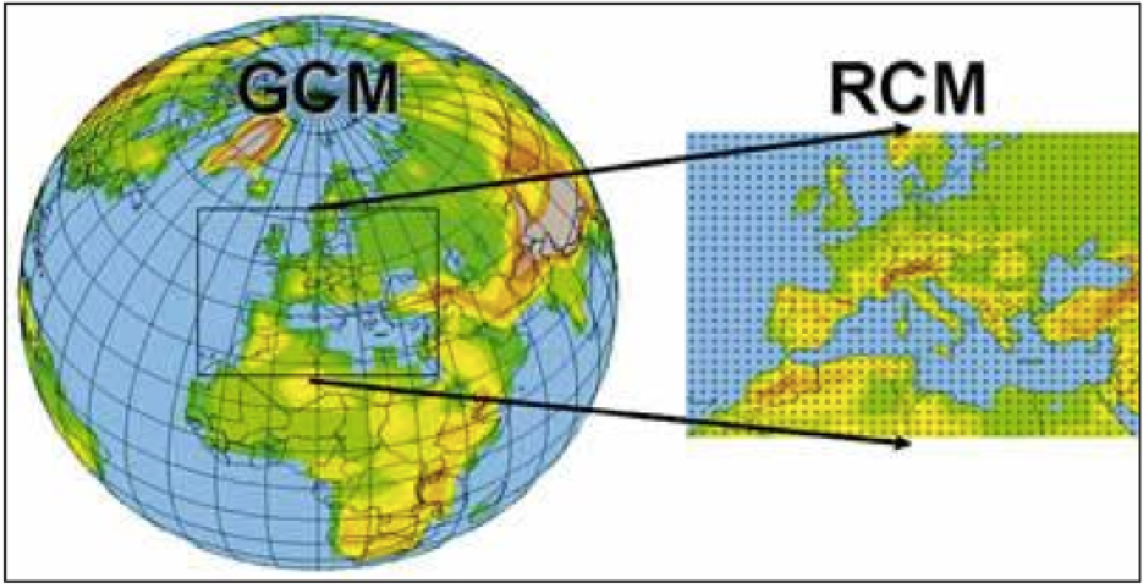
ΚΥΠΡΙΑΚΗ ΔΗΜΟΚΡΑΤΙΑ
ΥΠΟΥΡΓΕΙΟ ΓΕΩΡΓΙΑΣ, ΑΓΡΟΤΙΚΗΣ ΑΝΑΠΤΥΞΗΣ ΚΑΙ ΠΕΡΙΒΑΛΛΟΝΤΟΣ

ΤΜΗΜΑ ΠΕΡΙΒΑΛΛΟΝΤΟΣ
1498 ΛΕΥΚΩΣΙΑ

Purpose

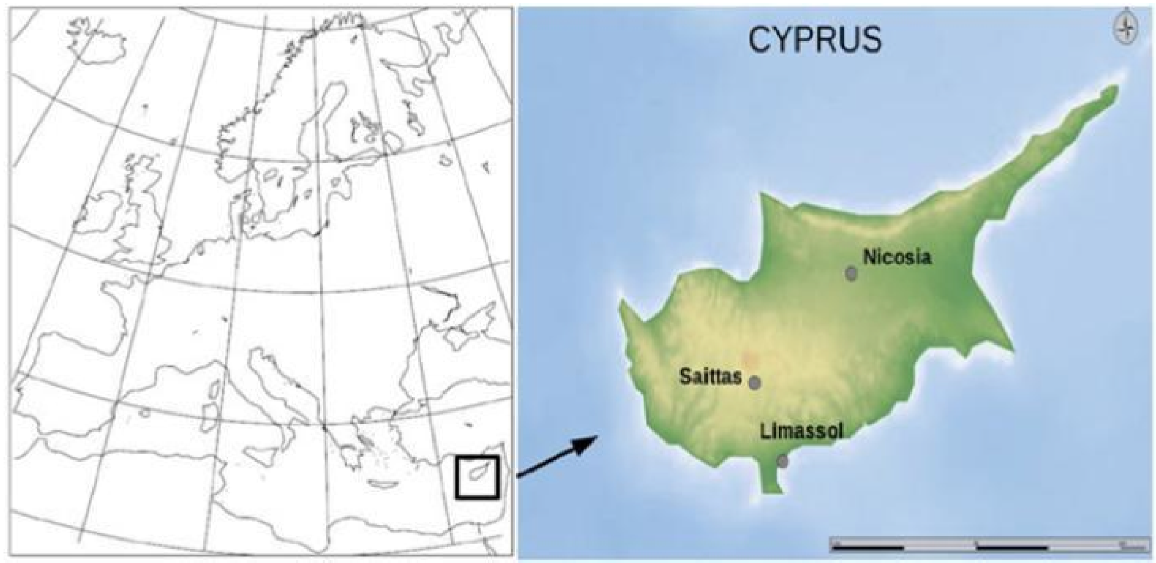
To provide up to date climate change information for Cyprus, using state-of-the-art regional climate models for different future scenarios and periods, to be used in the assessment of climate change impacts over this vulnerable island of the Eastern Mediterranean.

Regional climate modelling as a tool



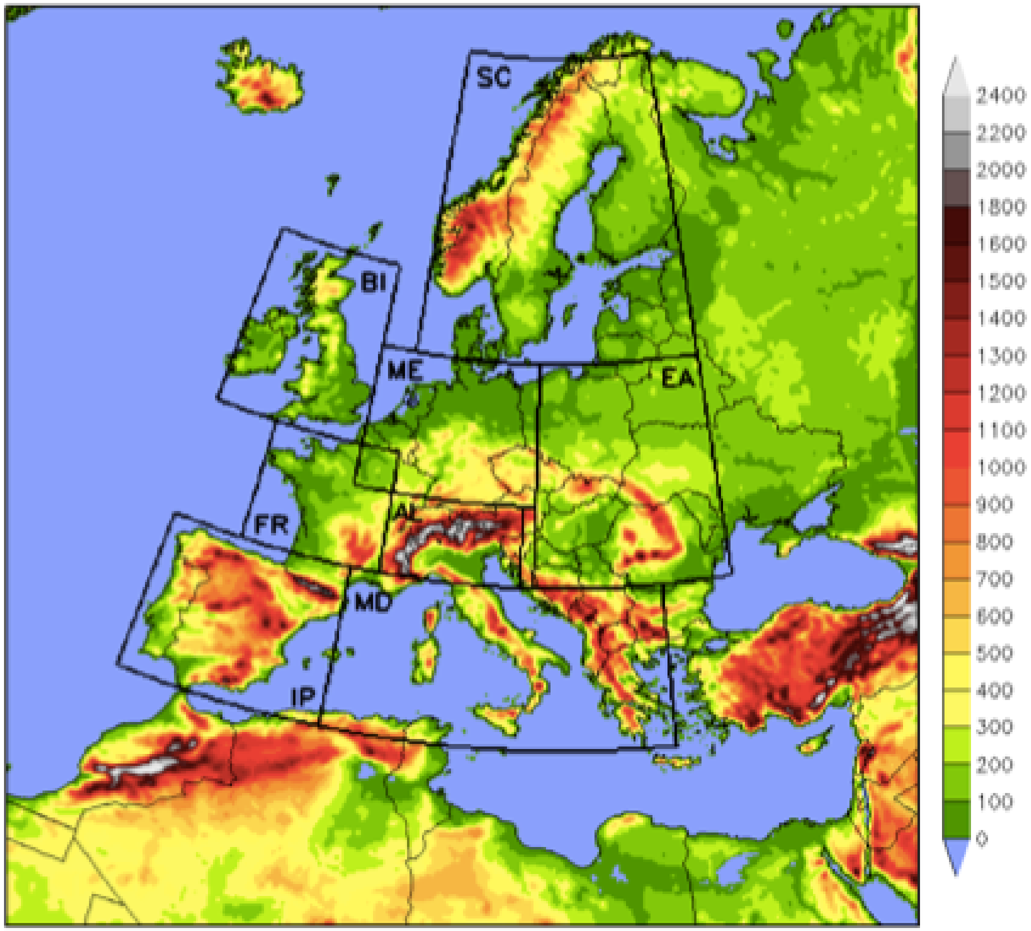
- Numerical modelling is the only tool that is available in present-day science for predicting future climate change.
- Global climate models that used to support the Intergovernmental Panel for Climate Change's (IPCC) reports are not suitable for a relatively small geographical region such as Cyprus
- High-resolution regional climate models (RCMs) are more suited tools for such a purpose, as they can resolve the varying meteorological behaviour in the different parts of the island .

Past climate change assessment for Cyprus: CYPADAPT and ENSEMBLES



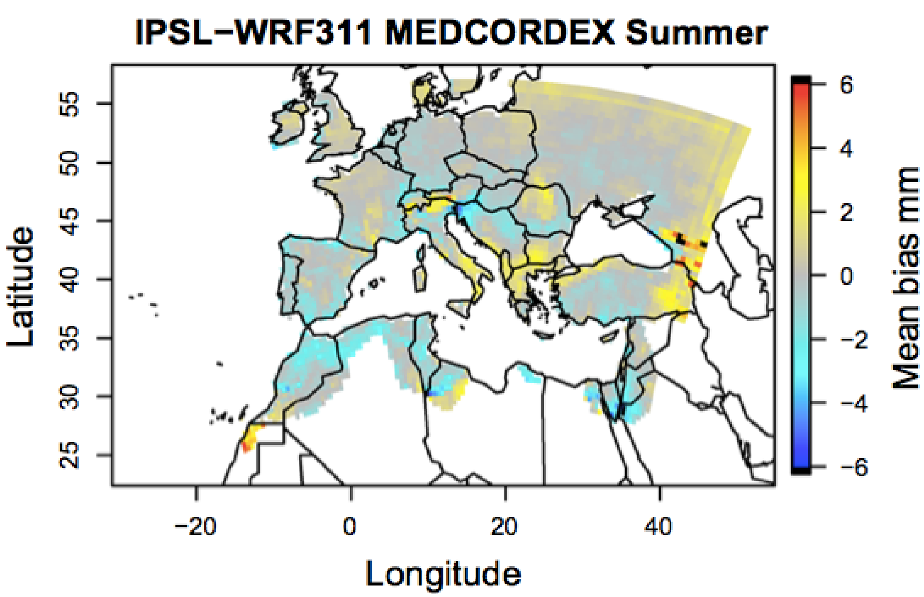
- CYPADAPT was a project that provided a national strategy for adaptation to climate change in Cyprus.
- As part of it, output from the PRECIS model (domain shown in the upper left) developed by the UK Met Office and run by the Cyprus Institute was used on a 25x25 km resolution.
- Additionally, results from models (also on 25x25 km resolution) that participated in the ENSEMBLES project were used. The RCM domain of those models and the key locations studied over Cyprus are shown on the upper right panel.

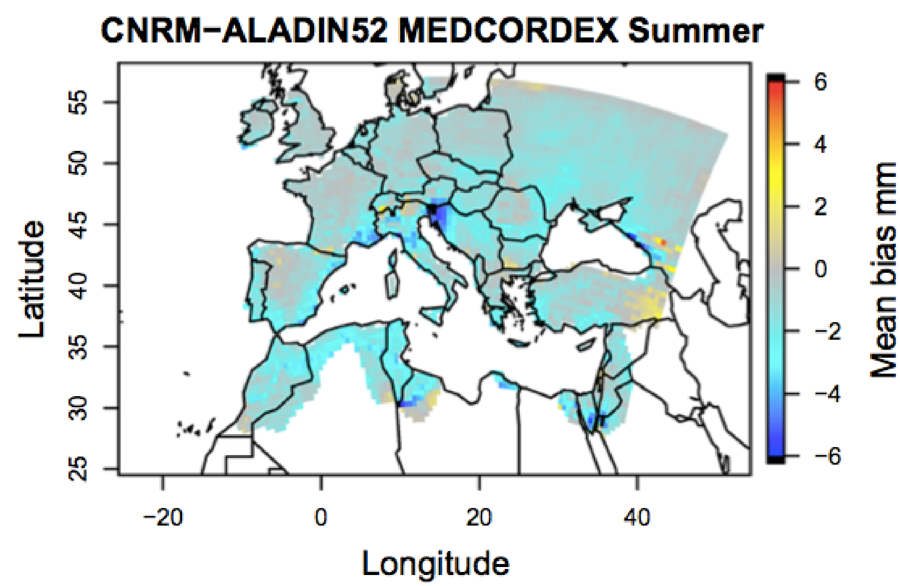
The CORDEX project



• Aims to, for the first time, intercompare multiple RCMs and produce climate change projections in a common format over key regions of interest. The EURO-CORDEX subproject focuses on Europe, and its domain is shown above (including sub-domains used in sub-projects).

MED-CORDEX: Another useful recent dataset

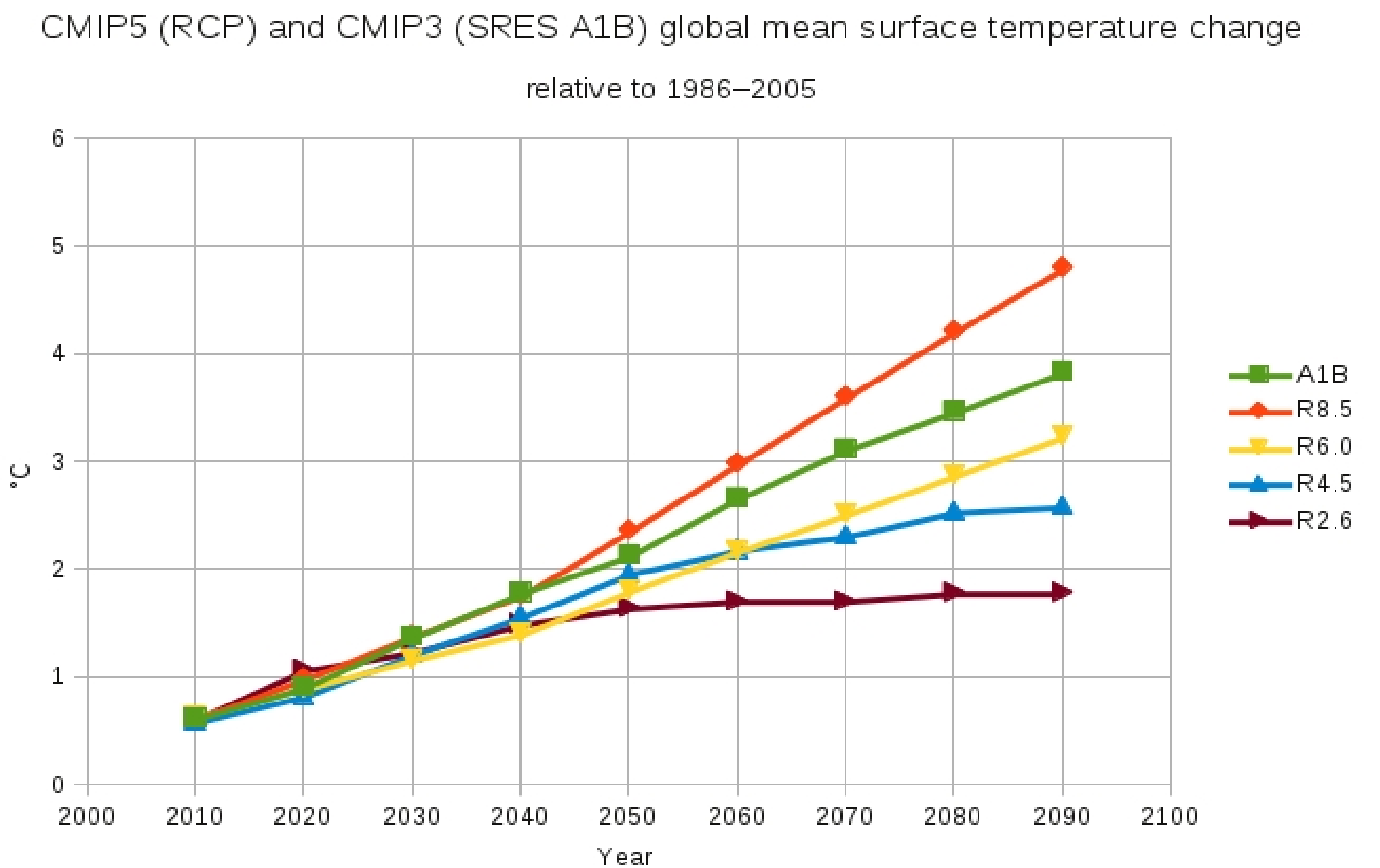




• MED-CORDEX is a CORDEX sub-project (separate to EURO-CORDEX), which focuses on simulating future climate change over the Mediterranean alone.

• The MED-CORDEX domain is shown above, as part of an example showing the precipitation evaluation of two of the MED-CORDEX models over the Mediterranean domain.

Scenarios used in EURO-CORDEX and MED-CORDEX simulations



- Shown is future global mean surface temperature change from CMIP5 (RCP) and CMIP3 (SRES A1B) scenarios. The former are used in CORDEX.

Advantages of our approach for CCRA

- The models used (2 EURO-CORDEX and 3 MED-CORDEX) are of a later generation than used before.
- We use higher resolution (12x12 km) models than in earlier work.
- The future scenarios used are more up to date. RCP4.5 & RCP8.5 are used, the former being more moderate and the latter being more severe.
- We thoroughly investigate changes in different climate parameters between the present-day and two future periods, i.e. 2050 & 2080.
- The models are initially evaluated against observations in order to assess their validity.
- The parameters selected have been chosen based on their usefulness for climate change impact assessment.

Imperial College London

Cyprus Climate Change Risk Assessment (CCRA)

“Αναλυτική περιγραφή των σεναρίων κλιματικής αλλαγής: Αποτελέσματα”

ΚΥΠΡΙΑΚΗ ΔΗΜΟΚΡΑΤΙΑ
ΥΠΟΥΡΓΕΙΟ ΓΕΩΡΓΙΑΣ, ΑΓΡΟΤΙΚΗΣ ΑΝΑΠΤΥΞΗΣ ΚΑΙ ΠΕΡΙΒΑΛΛΟΝΤΟΣ

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2. Brief description of present-day climatology

3. Climate change by year 2050 for two climate scenarios (RCP4.5 and RCP8.5)

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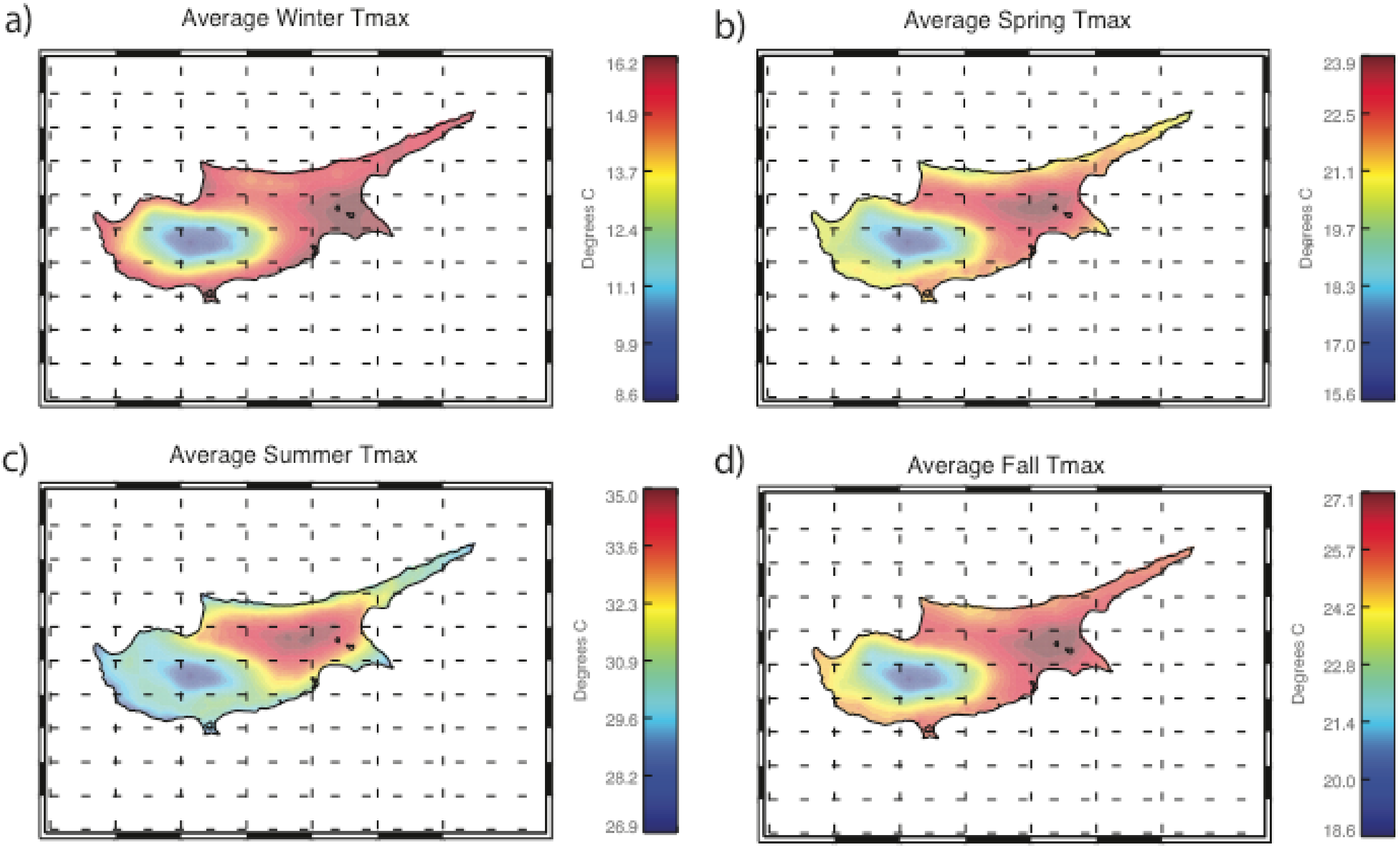
5. Other aspects of our work

6. Conclusions

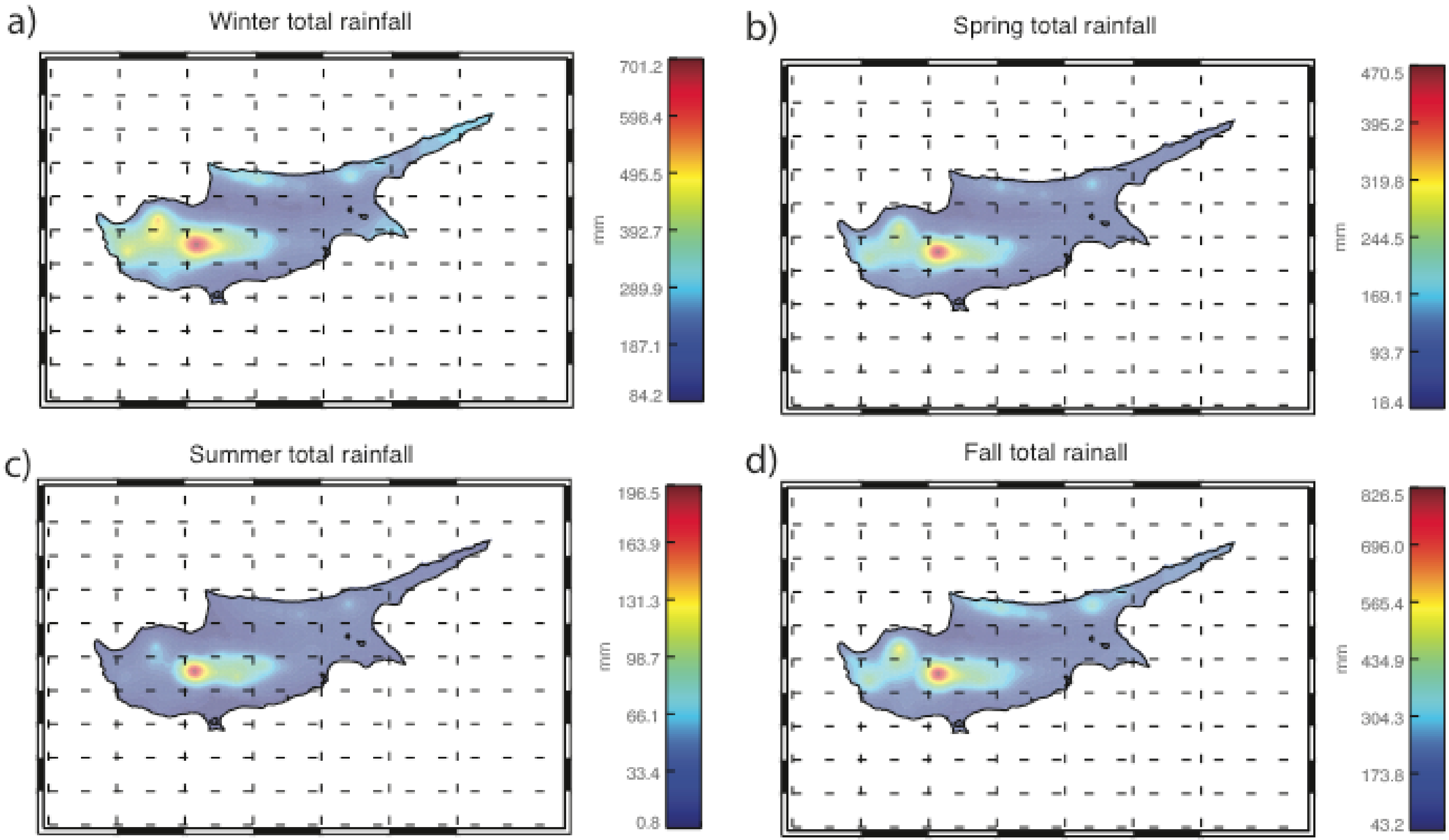
Brief description of present-day climatology

Present-day Tmax



- Decreasing tendency with altitude. In the summer, the western part of the island is significantly cooler than the eastern.

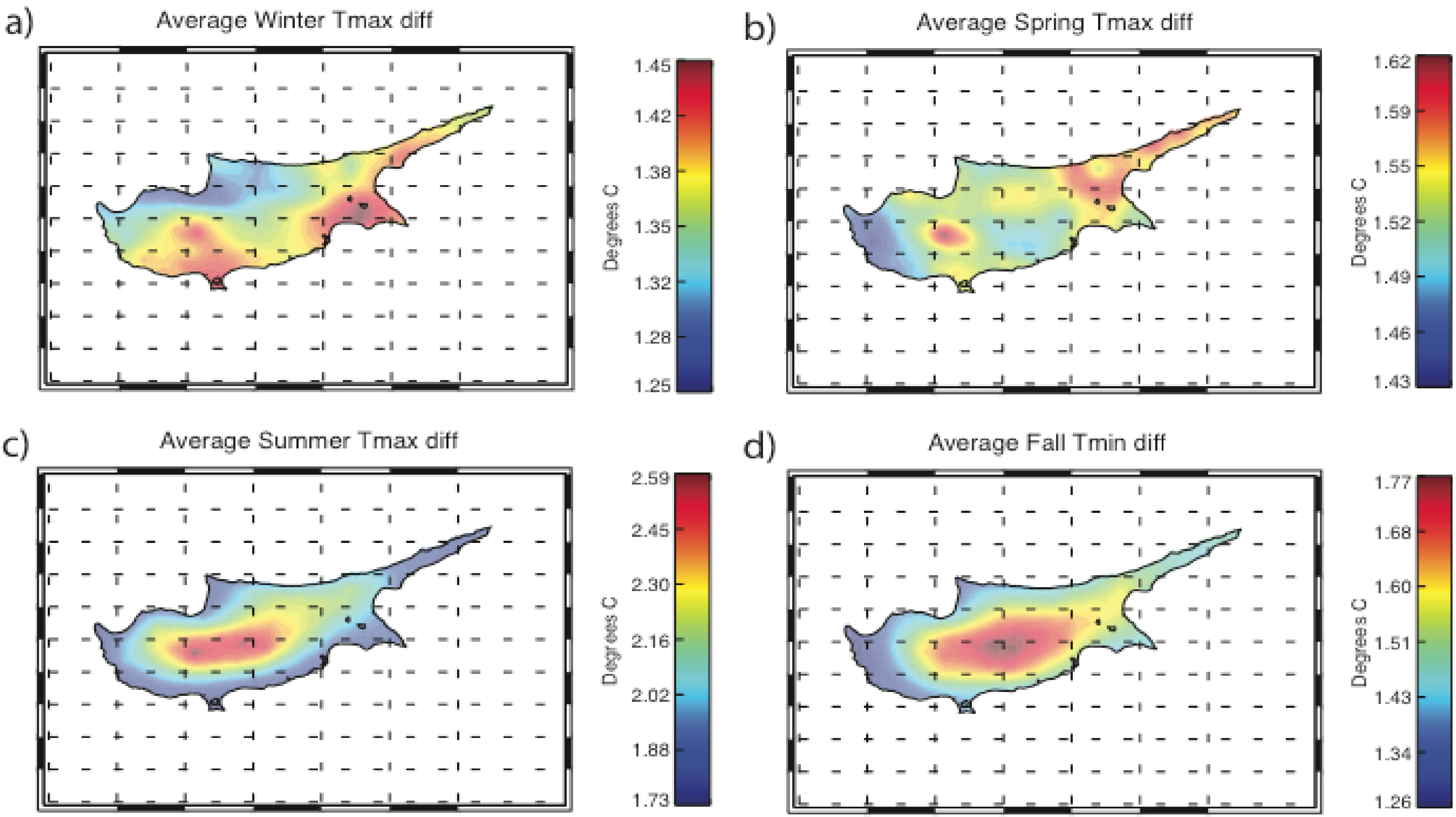
Present-day seasonal precipitation



- Precipitation increases with altitude, as expected. Western coastal areas are the second wettest in the winter, while continental lowland areas are the second wettest in the summer.

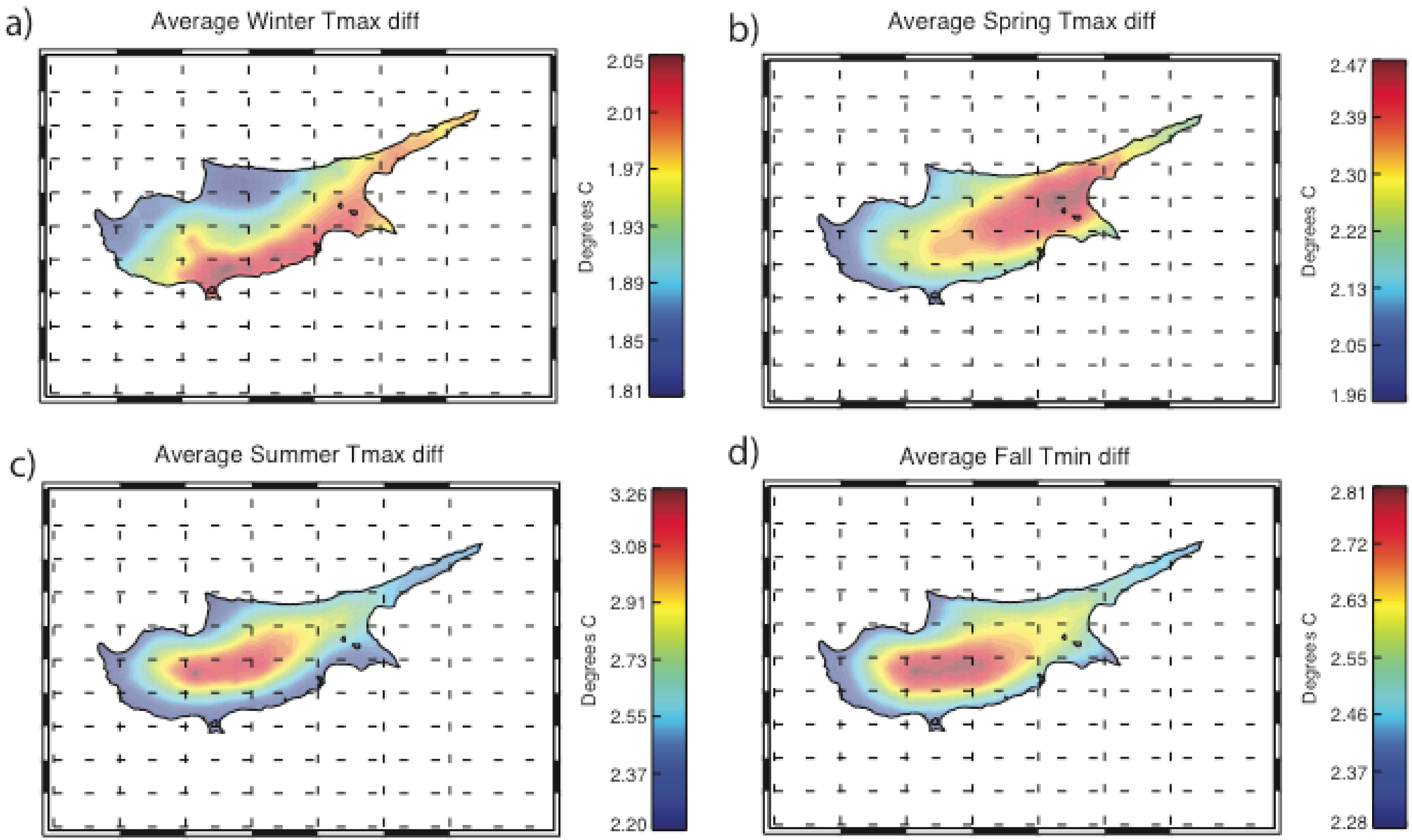
Climate change by year 2050 for two climate scenarios (RCP4.5 and RCP8.5)

Changes in Tmax by 2050 in RCP4.5



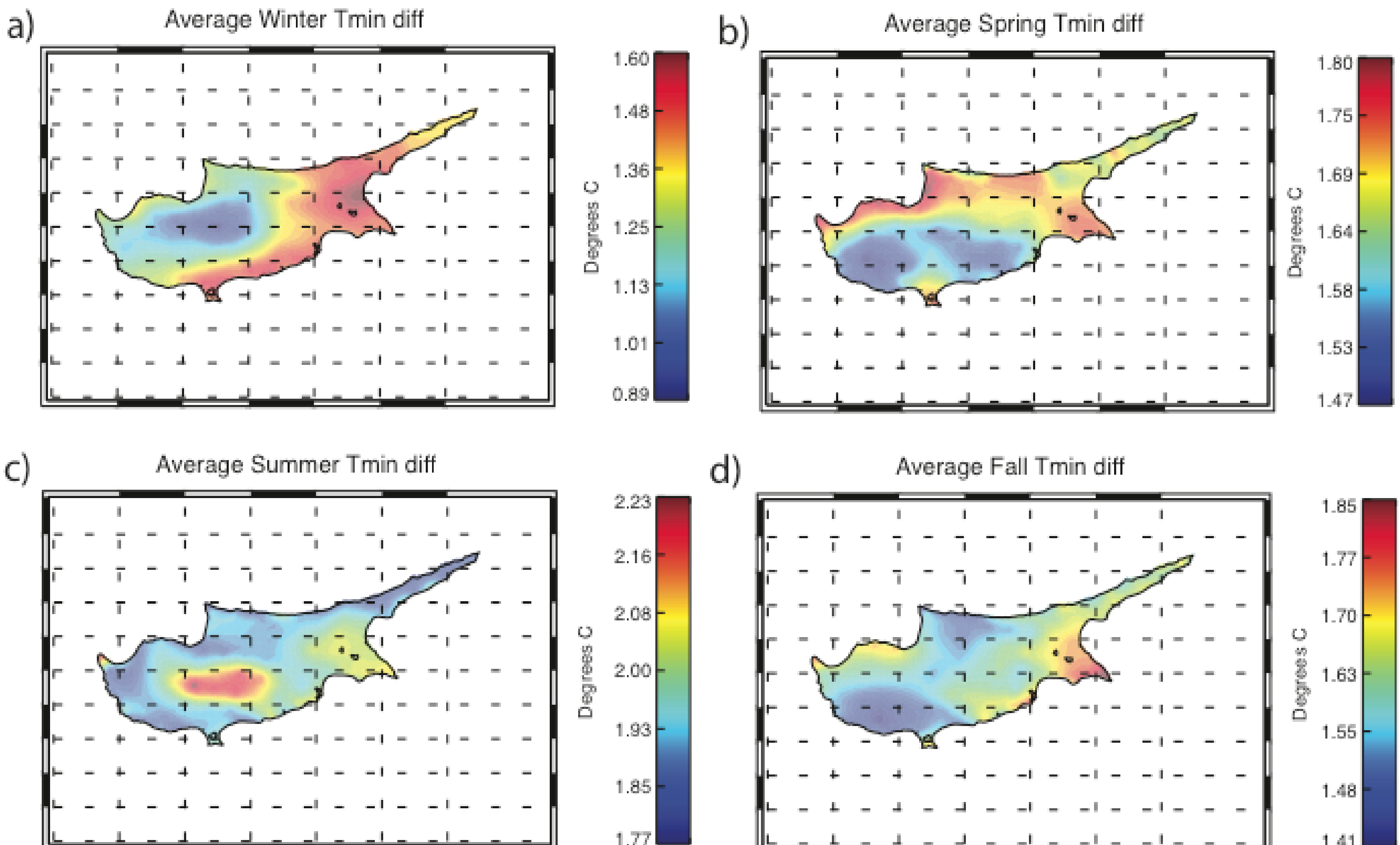
- Increases everywhere. In the summer & fall, clear tendency for stronger increases in the continental areas. In the winter & spring, more complex. The western coastal areas generally show the smallest changes.

Changes in Tmax by 2050 in RCP8.5



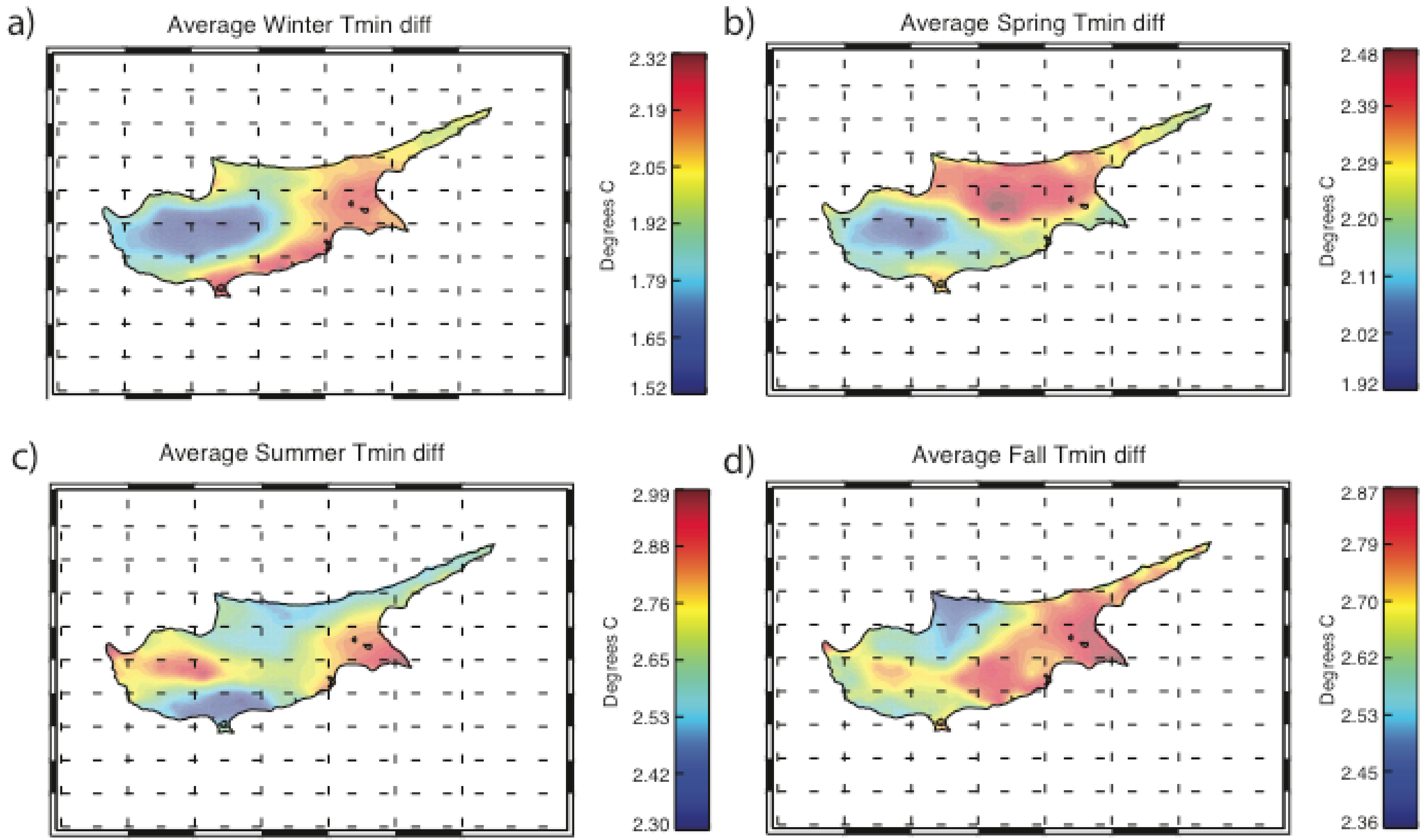
- Generally similar pattern to RCP4.5. Though larger changes, for all seasons. Largest changes in the summer.

Changes in Tmin by 2050 in RCP4.5



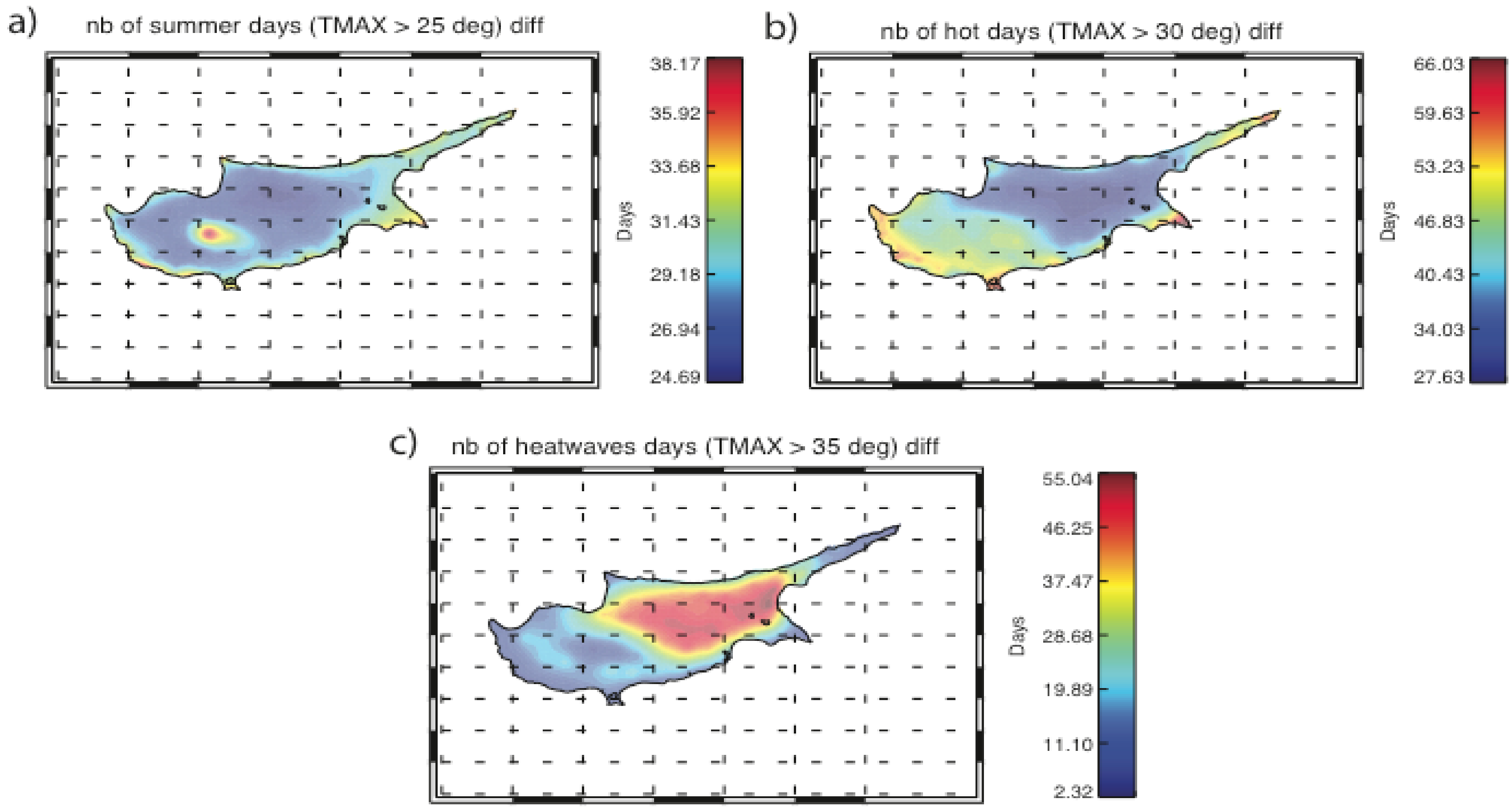
- Again, increases everywhere, and again strongest in the summer. Peak in high elevation areas only for the summer. In the winter, those areas show the smallest decreases.

Changes in Tmin by 2050 in RCP8.5



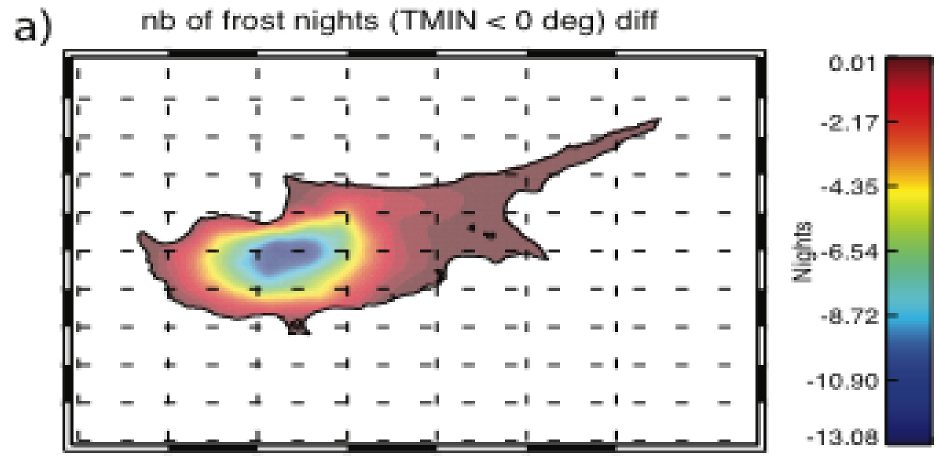
- Stronger increases, largest in eastern coastal areas in the summer and fall. Pattern not very similar to that for RCP4.5, except for the winter.

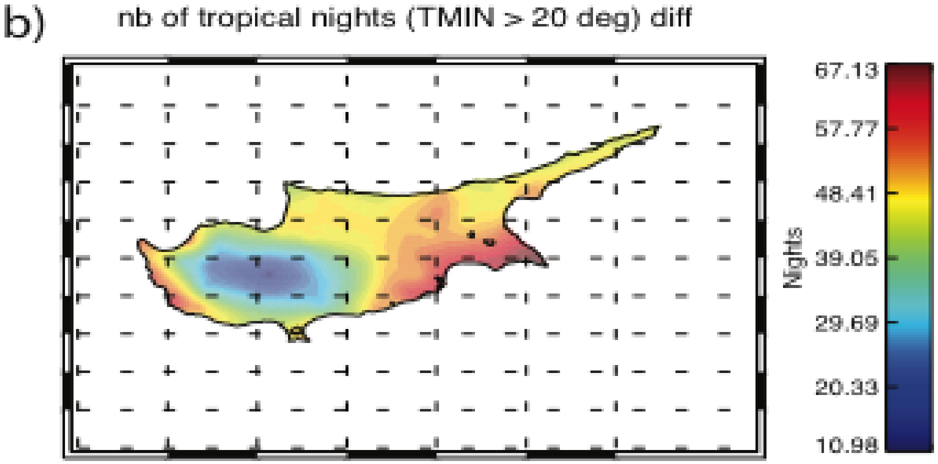
Changes in temperature extremes by 2050 in RCP8.5 (I)



- Drastic increases of all the metrics. Number of heatwaves increases more in the continental lowland areas.

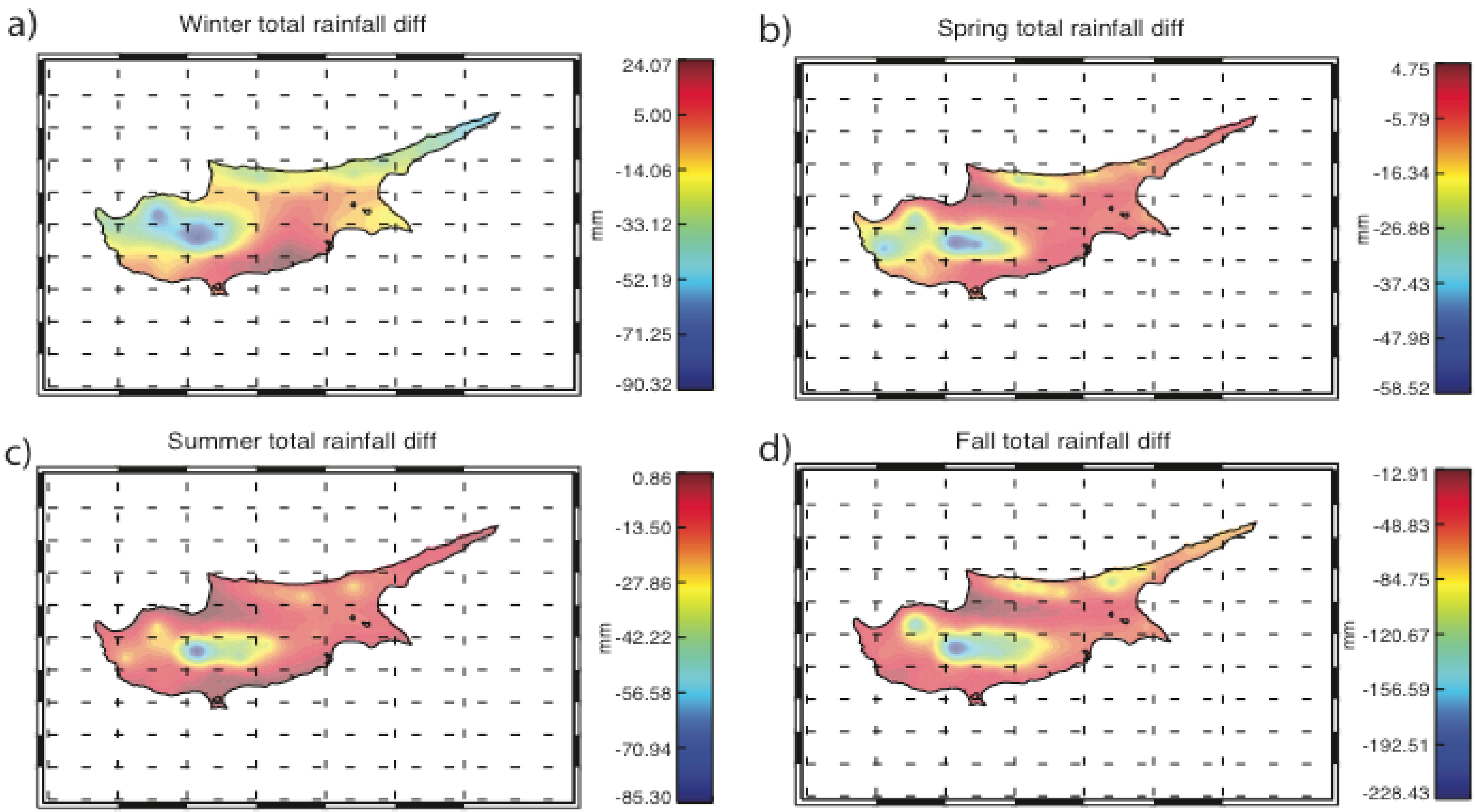
Changes in temperature extremes by 2050 in RCP8.5 (II)





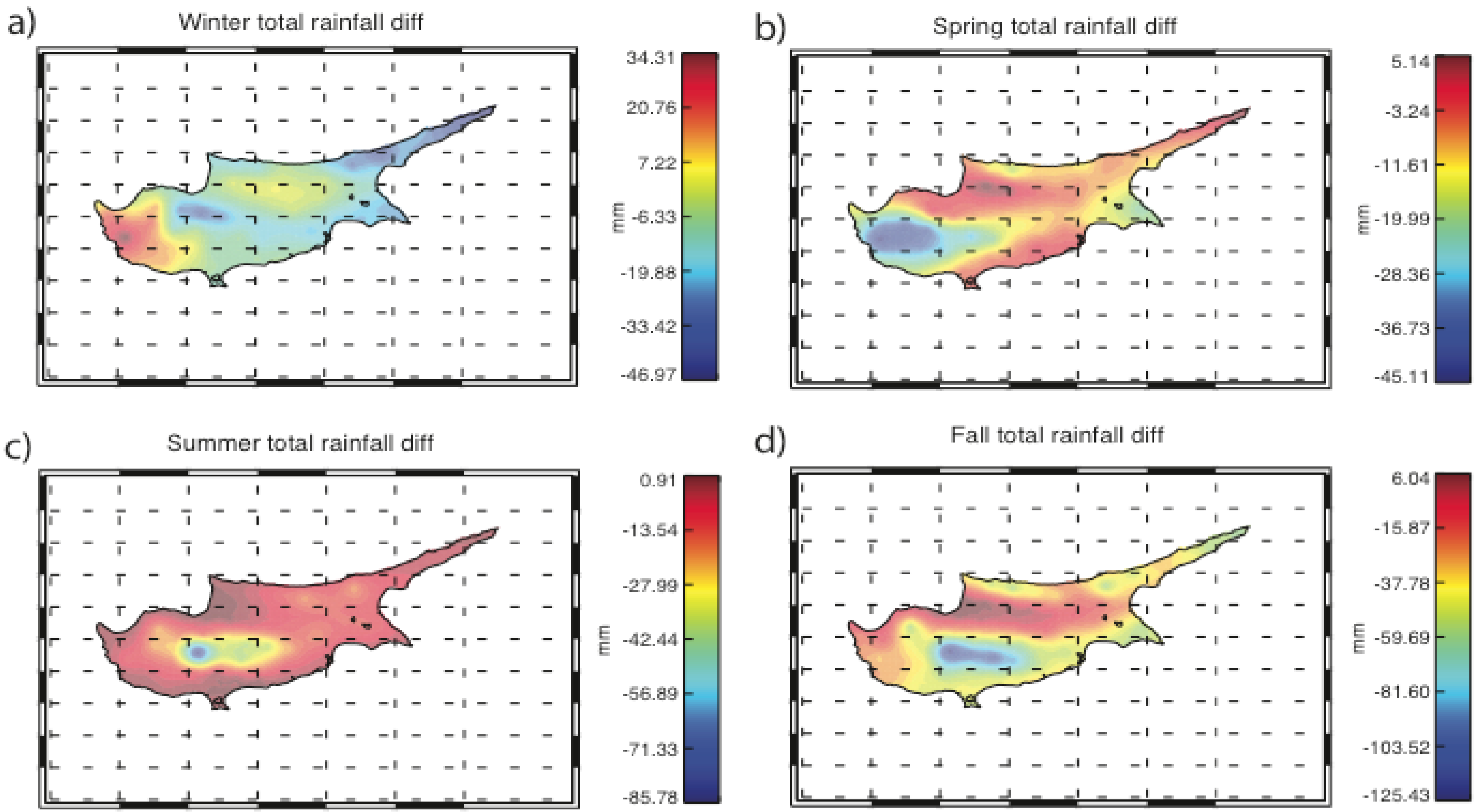
- Frost nights decrease everywhere, but more in the high elevation areas. Tropical nights increase more in the coastal areas, especially in the southeast.

Changes in precipitation by 2050 in RCP4.5



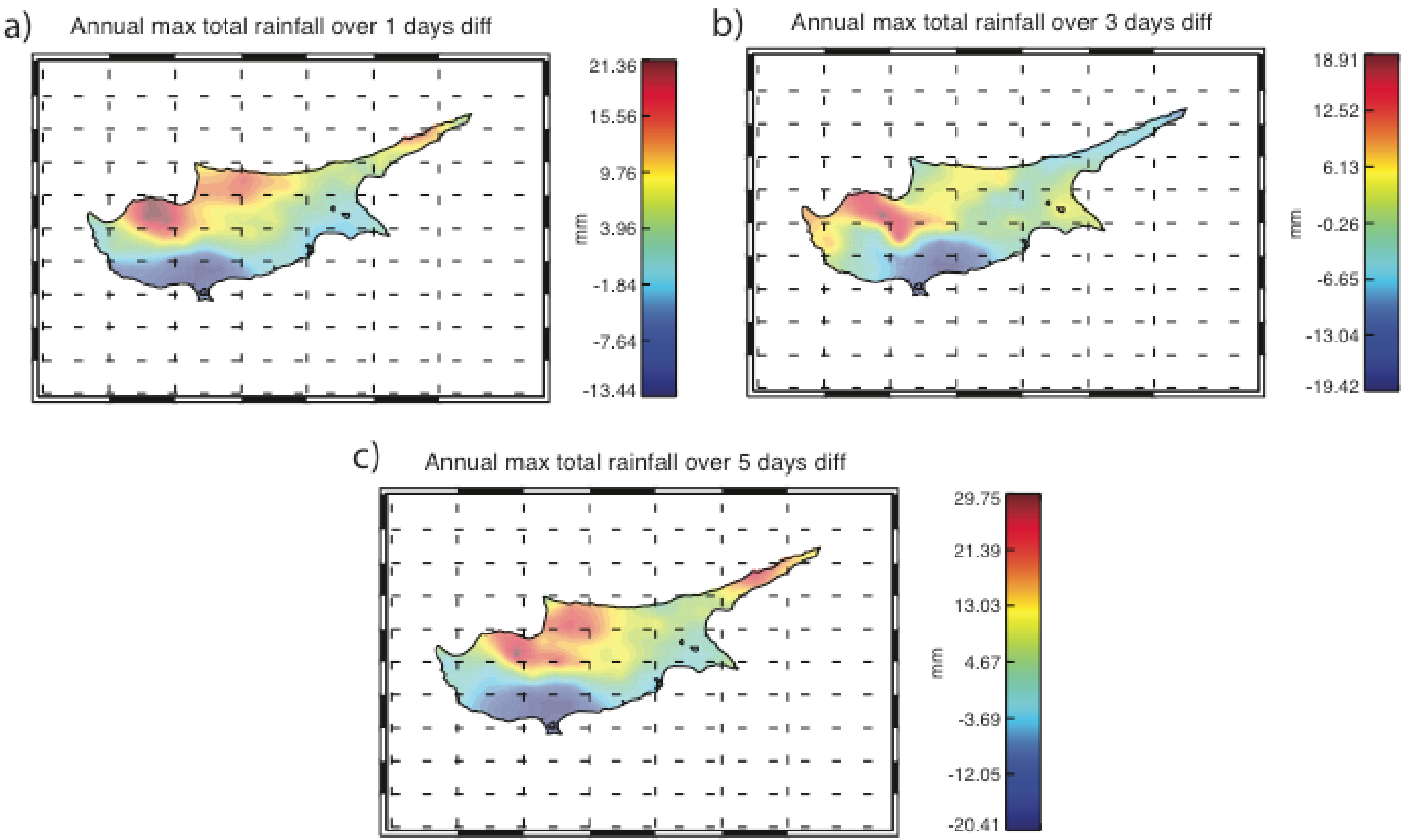
- Mostly decreases, strongest in high elevation areas, especially in the fall.

Changes in precipitation by 2050 in RCP8.5



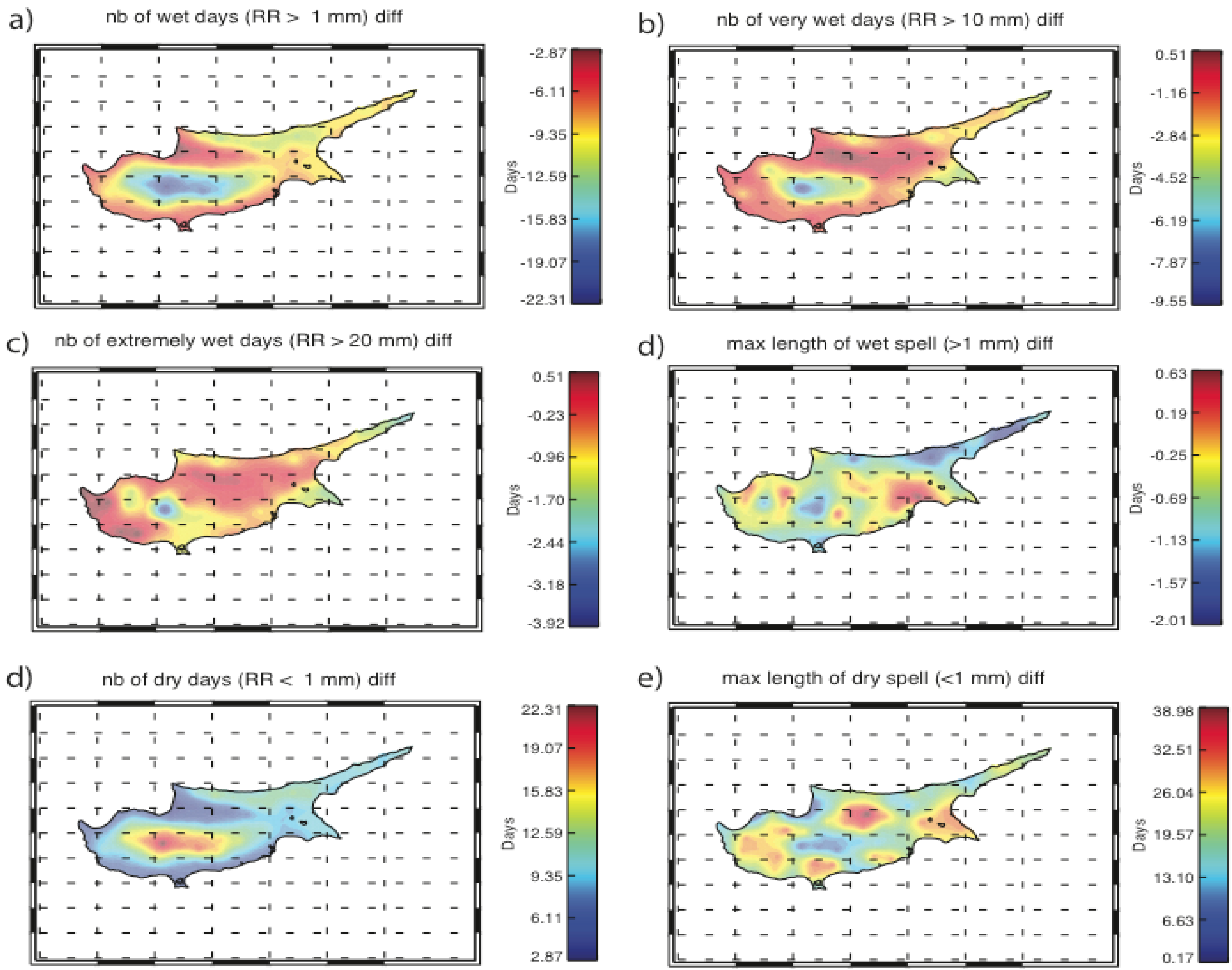
- Drying prevails. Pattern of changes different compared to RCP4.5, but only slightly. Changes are similar for the spring & summer and smaller for the winter & fall.

Changes in precipitation extremes by 2050 in RCP8.5 (I)



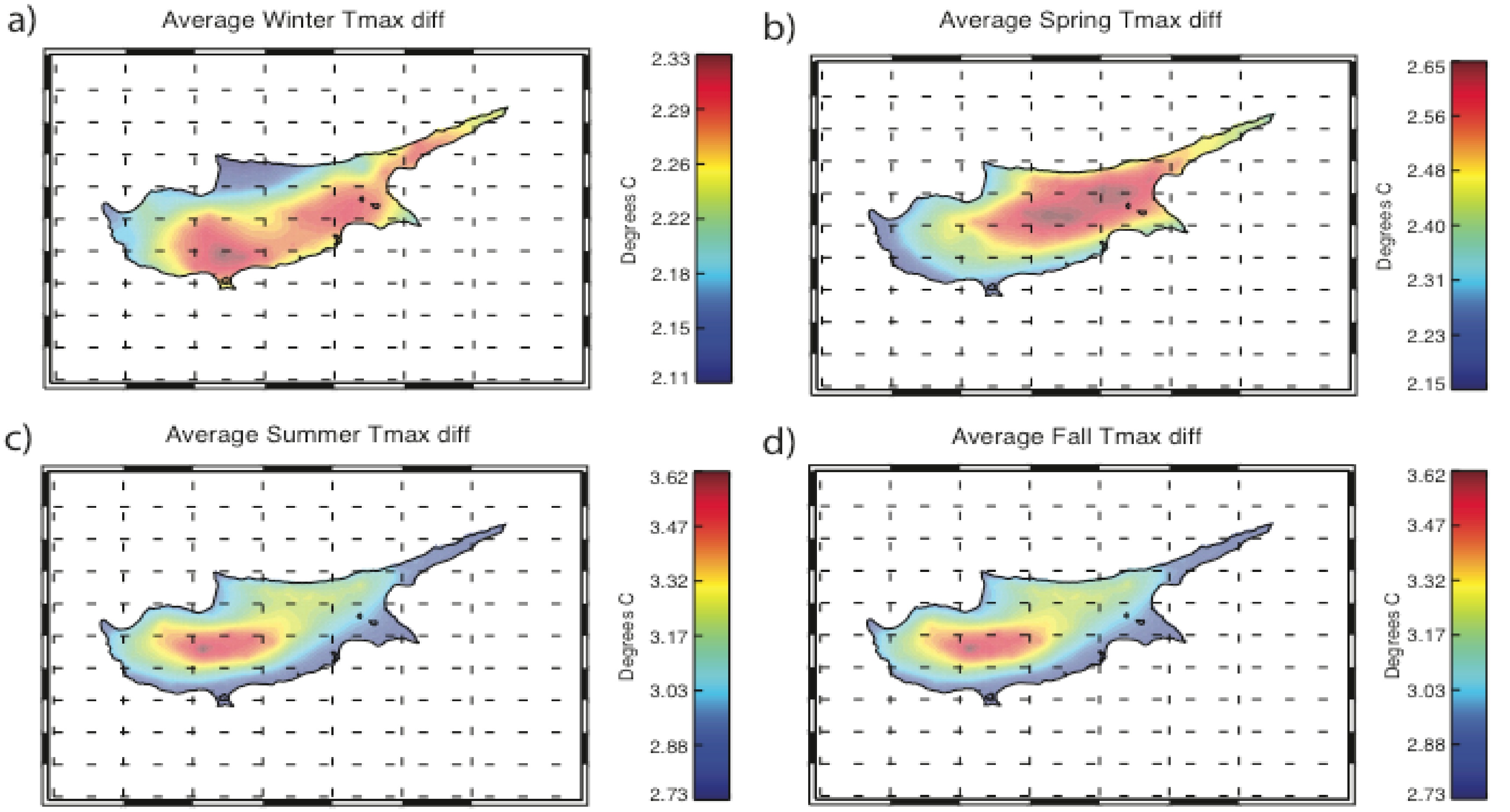
- Tendency for the north+west to experience more extreme rainfall, while the south+east experience less.

Changes in precipitation extremes by 2050 in RCP8.5 (II)



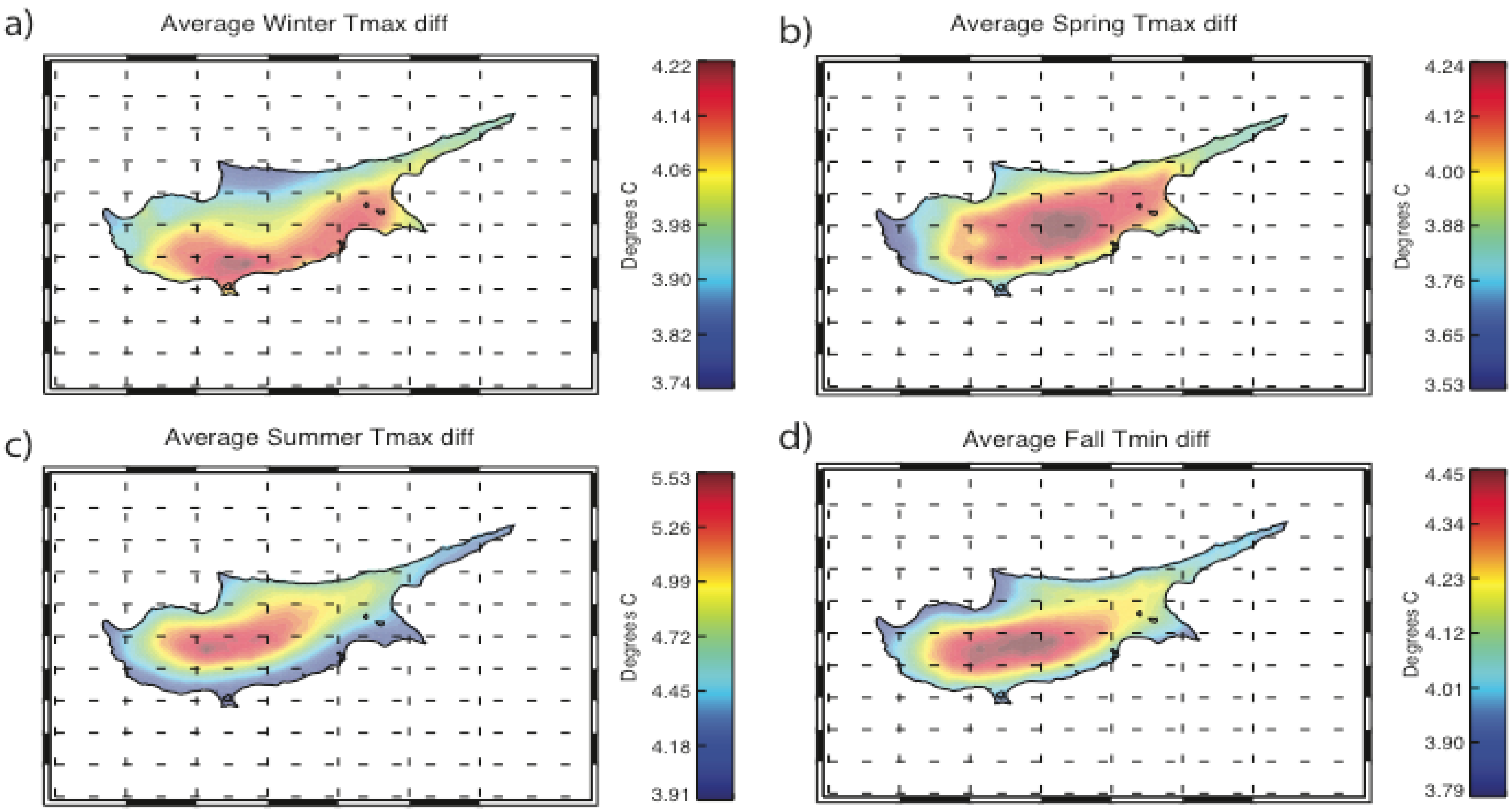
Climate change by year 2080 for two climate scenarios (RCP4.5 and RCP8.5)

Changes in Tmax by 2080 in RCP4.5



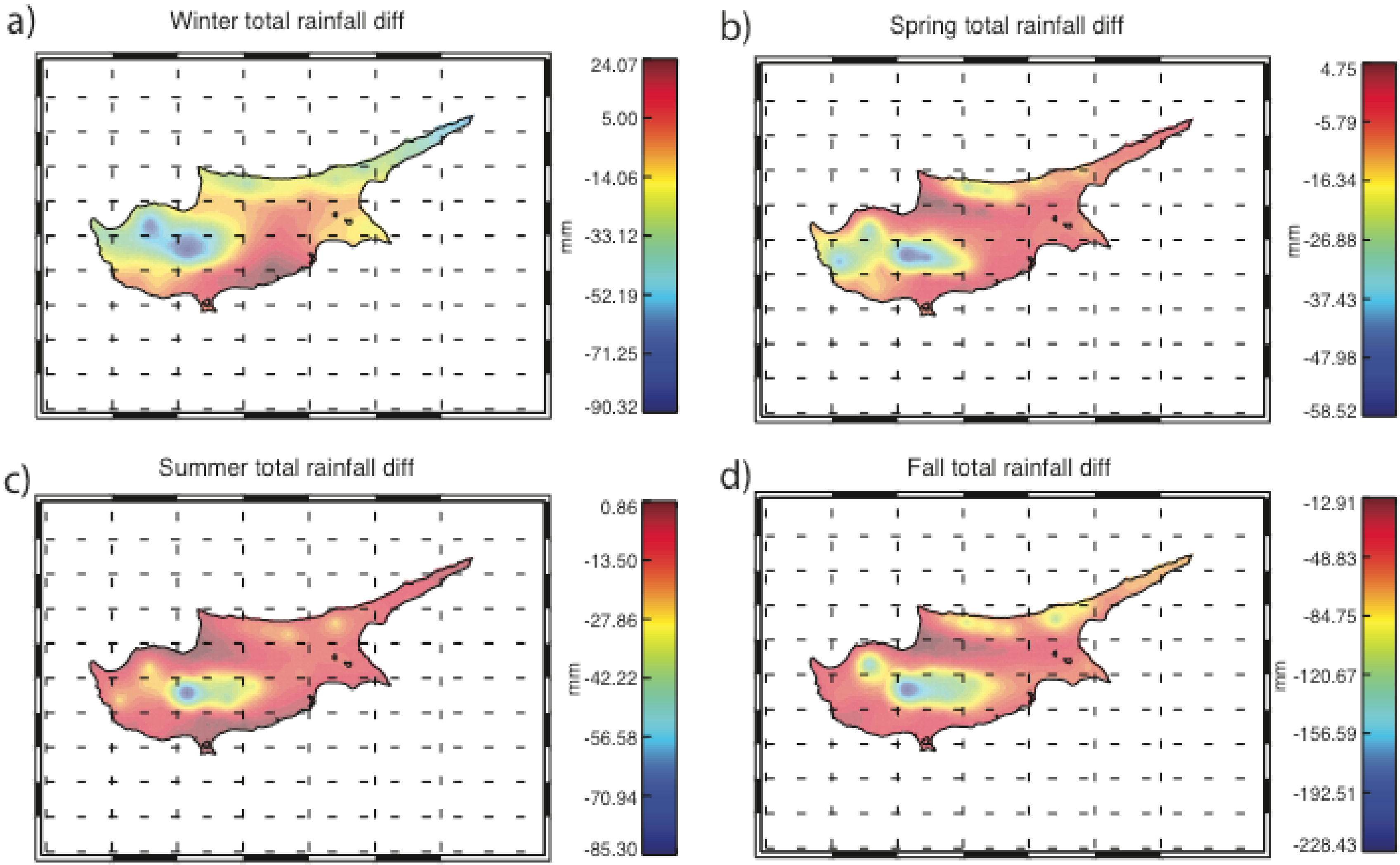
- Increases everywhere. As for 2050, in the summer & fall, tendency for stronger increases in the continental areas. In the winter & spring, more complex. The coastal areas generally show the smallest changes.

Changes in Tmax by 2080 in RCP8.5



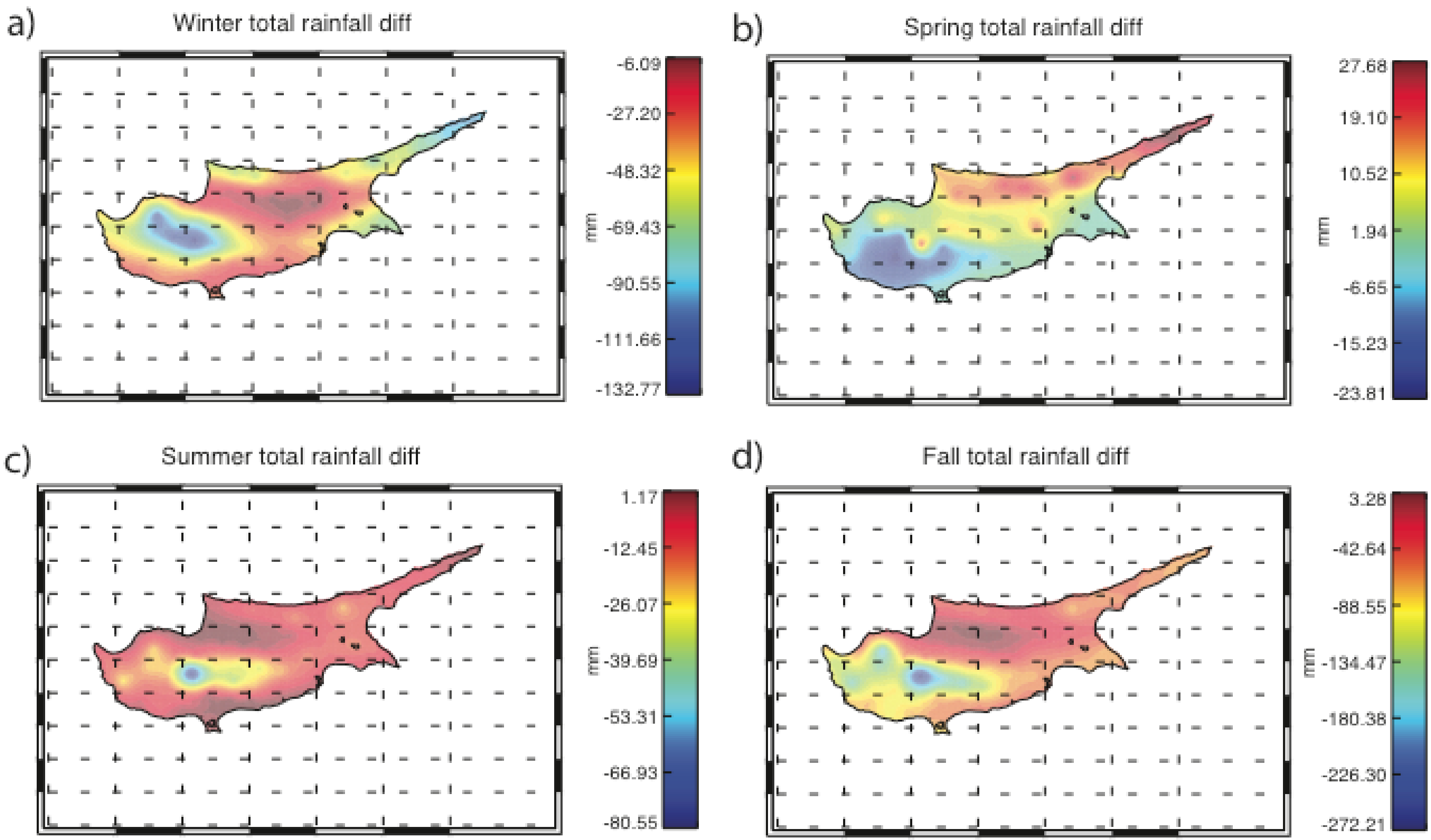
- Generally similar pattern to RCP4.5. Though larger changes, for all seasons. Largest changes in the summer, as for 2050.

Changes in precipitation by 2080 in RCP4.5



- As for 2050, mostly decreases, strongest in high elevation areas, especially in the fall.

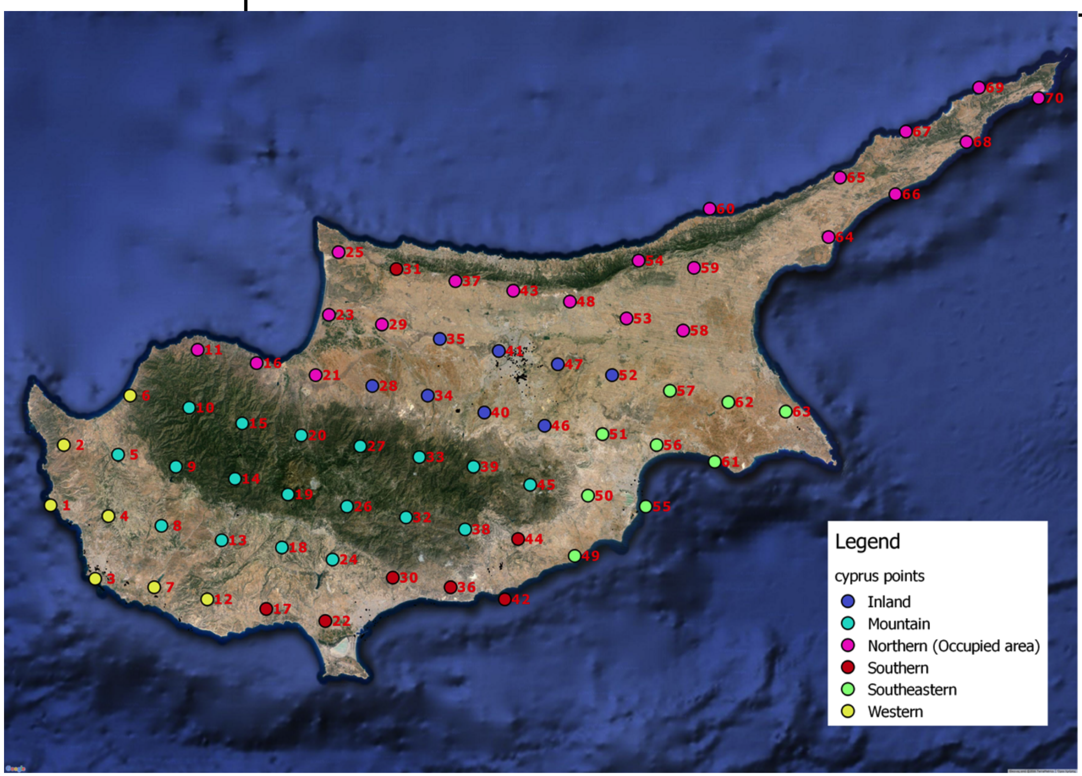
Changes in precipitation by 2080 in RCP8.5



- Drying prevails (less so in spring). Pattern of changes somewhat different compared to RCP4.5. Changes are similar for the summer & fall, smaller for the spring, and larger for the winter.

Also: Below are the regions for which present-day and future climate were summarised in tables

Western Coastal Areas (the greater area of Paphos)
Southern Coastal Areas (the greater area of Limassol)
Eastern Coastal Areas (the greater area of Famagusta, Ayia Napa and Larnaca)
Continental Lowland Areas (the greater area of Nicosia)
Higher Elevation Areas (the central part of Troodos mountains).



- Five geographical areas with distinct meteorological features.
- Each point on the map represents one model grid-point, while the colouring indicates which region it corresponds to.

Example of table showing regional mean changes

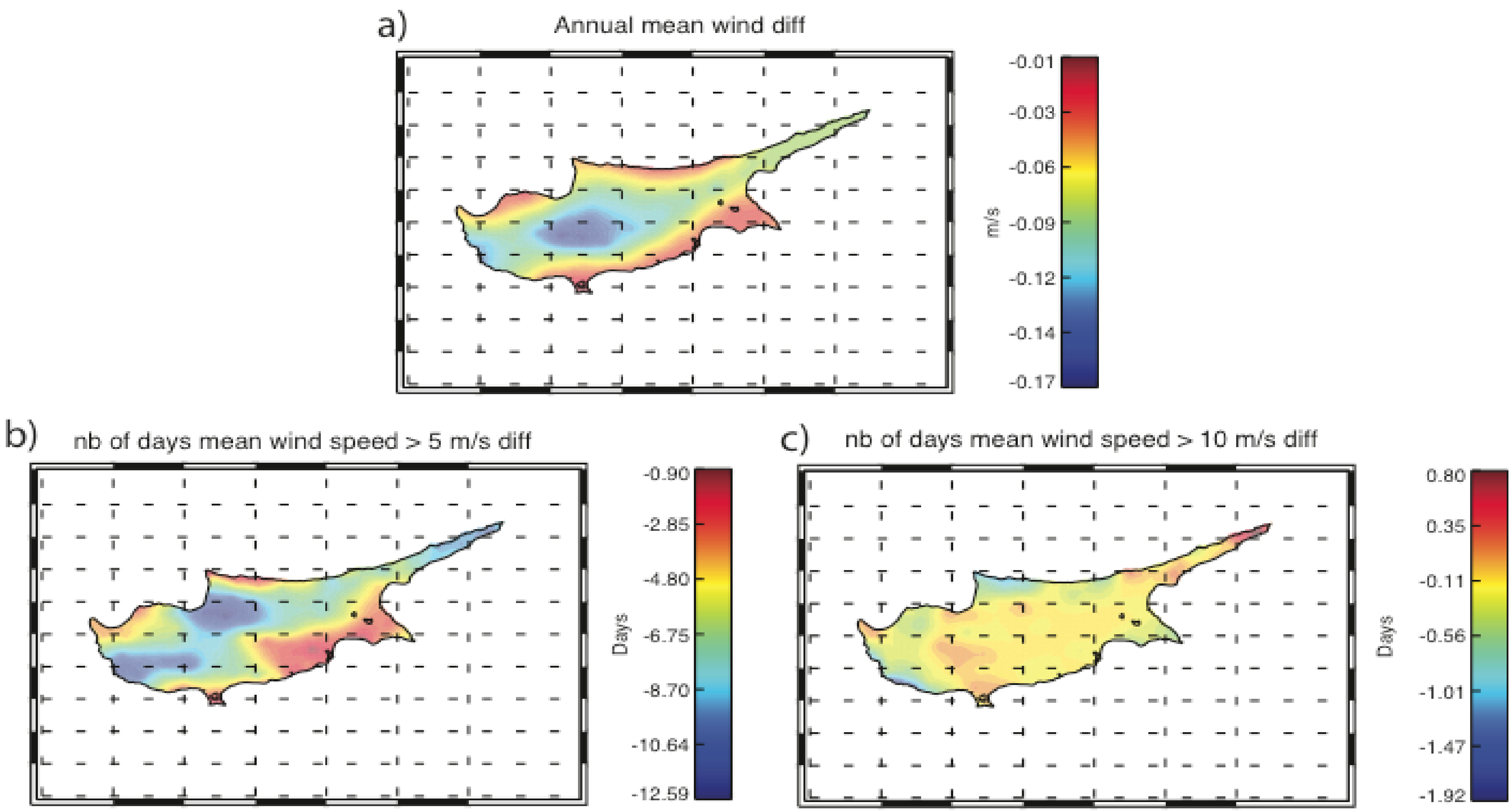
INDEX	Western Coastal Areas	Southern Coastal Areas	Eastern Coastal Areas	Continental Lowland Areas	High Elevation Areas
Temperature (°C | days/yr)					
WAVTMX	2.9±0.6	3.0±0.6	3.0±0.6	3.1±0.6	2.9±0.6
SPAVTMX	3.5±0.5	3.6±0.5	3.8±0.7	4.0±0.8	4.1±0.9
SUAVTX	3.5±0.5	3.5±0.4	3.6±0.5	4.1±0.5	4.3±0.5
FAVTX	3.3±0.4	3.3±0.4	3.3±0.4	3.4±0.5	3.6±0.5
WAVTMN	2.8±0.5	2.9±0.6	3.0±0.5	3.1±0.5	2.4±0.5
SPAVTMN	3.3±0.4	3.6±0.4	3.7±0.4	3.9±0.4	3.4±0.6
SUAVTMN	4.0±0.5	4.0±0.5	4.3±0.6	4.3±0.6	4.6±0.5
FAVTMN	3.7±0.4	3.8±0.5	4.0±0.5	4.0±0.5	3.8±0.5
NbSUMDAY	52.0±11.8	51.4±12.1	46.2±5.8	43.2±4.2	48.8±7.1
NbHOTDAY	61.0±8.0	61.0±8.0	57.0±5.1	48.0±6.8	53.0±11.2
NbHEATDAY	23.0±8.1	23.0±8.1	44.0±8.6	55.8±11.5	29.6±9.9
NbTRONIGH	66.0±12.4	67.0±12.5	76.0±12.4	71.6±12.4	47.0±25.6
NbFRONIGH	-4.0±8.0	-4.0±8.0	-2.0±4.0	-4.0±8.0	-15.0±13.3

- Changes in temperature metrics for RCP8.5 2080 are shown on the table for the five different regions.

Main conclusions

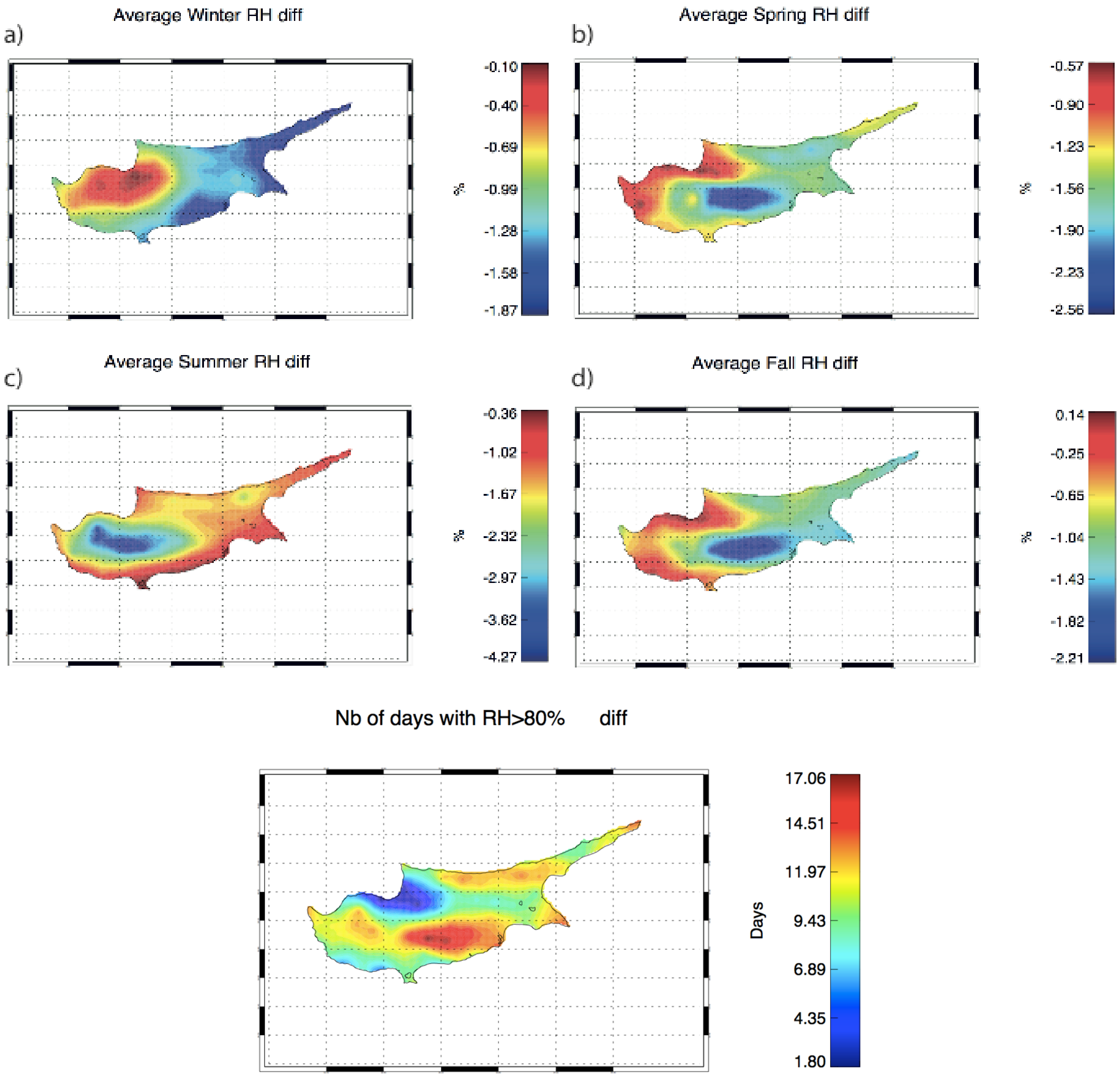
- Strong temperature increases in the future over the island (up to 4.5°C in high elevation areas in the summer by 2080 in the RCP8.5 scenario).
- Significant changes in temperature extremes (e.g. from 23 to 56 additional heatwave days per year).
- Less confidence in precipitation changes. Clearest feature is decrease in high elevation areas in RCP8.5.
- Number of wet days decreasing by 16 in RCP8.5 by 2080.
- Hint of wind decreases in the RCP8.5 scenario.
- Minor decreases in relative humidity in all regions, primarily in high elevation areas.
- Possible sea level rise of ~0.5, though prediction is uncertain.

Changes in wind metrics by 2050 in RCP8.5

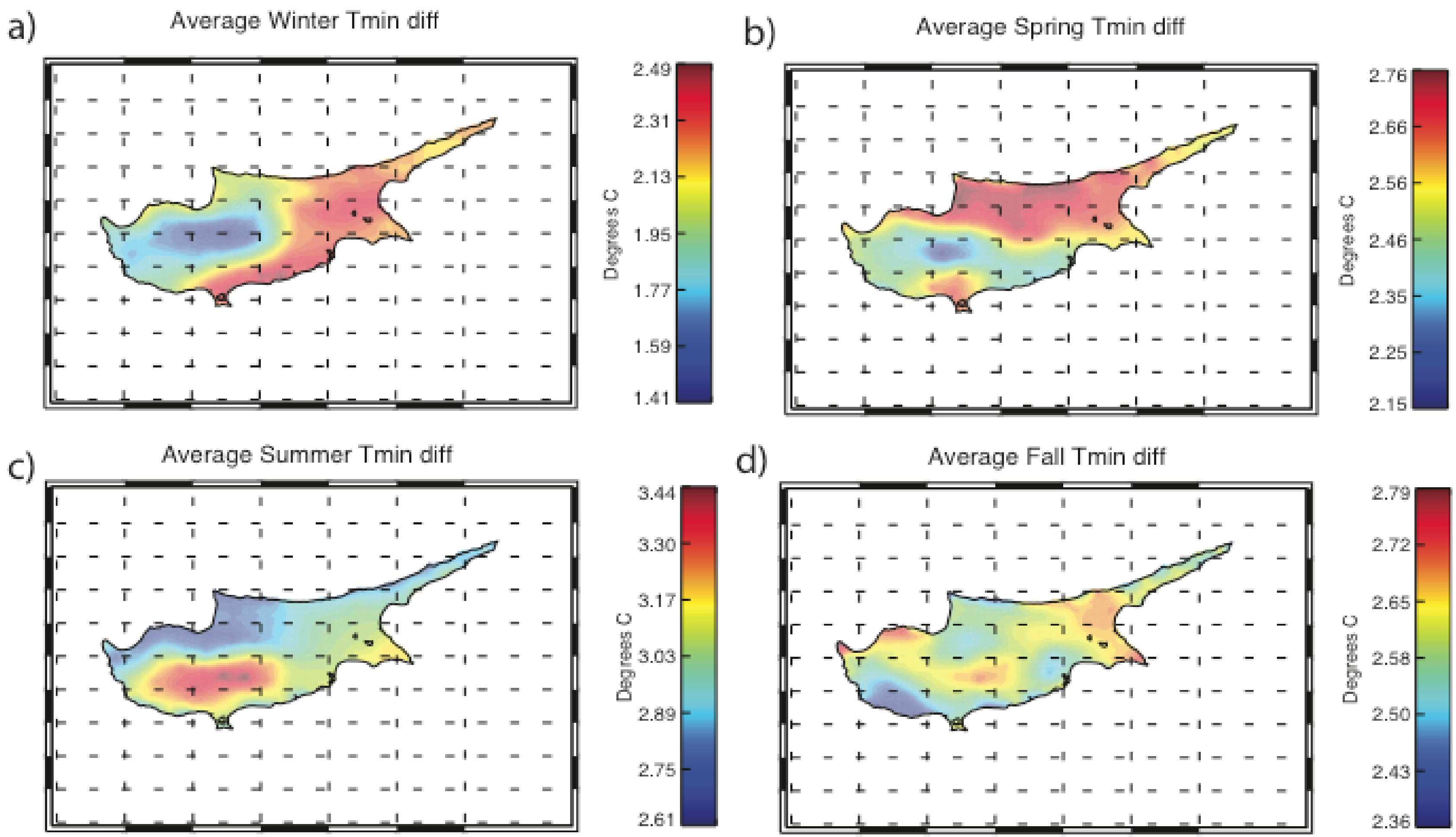


- Mostly minor changes in the winds. Tendency for a general decrease.

Changes in relative humidity metrics by 2050 in RCP8.5

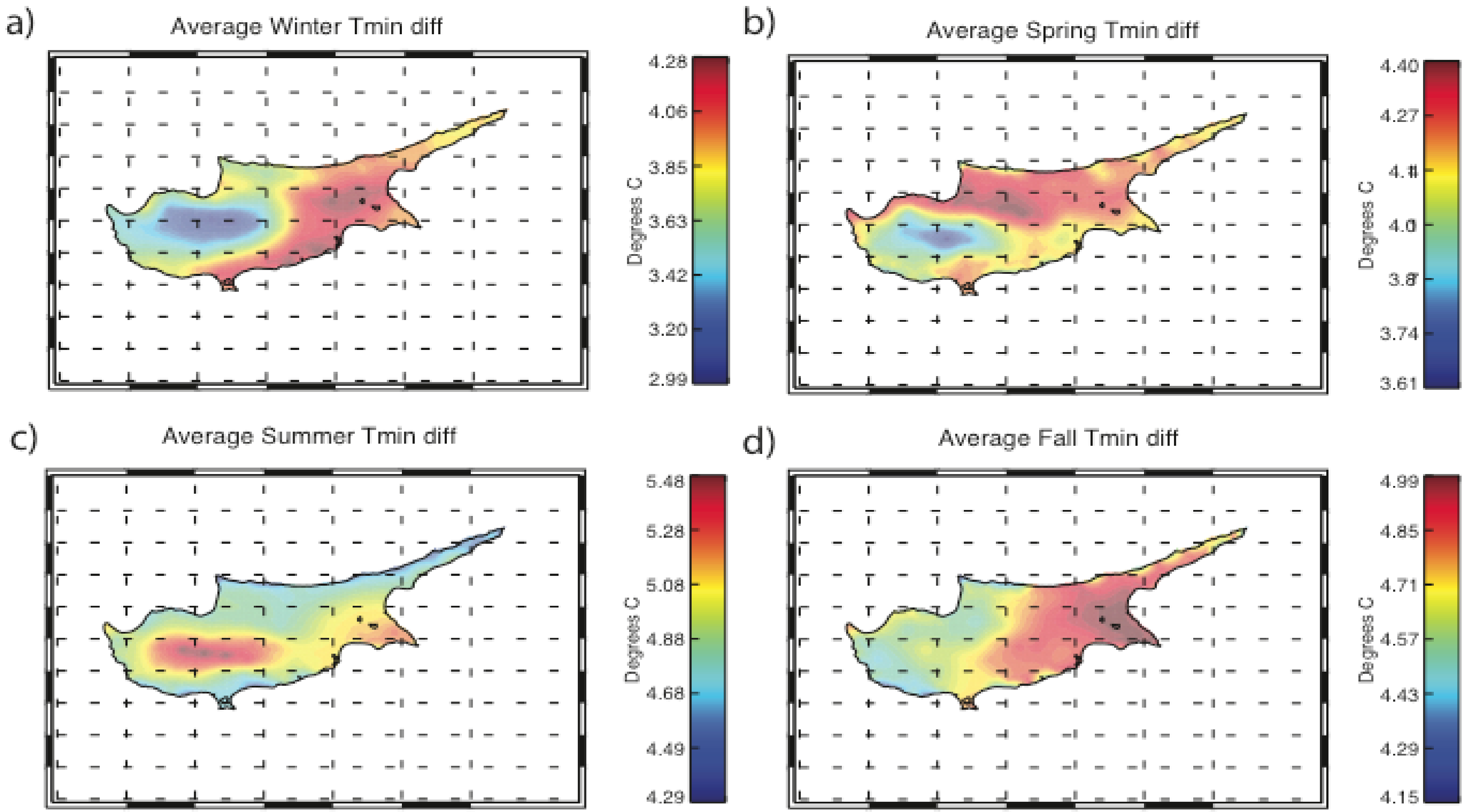


Changes in Tmin by 2080 in RCP4.5



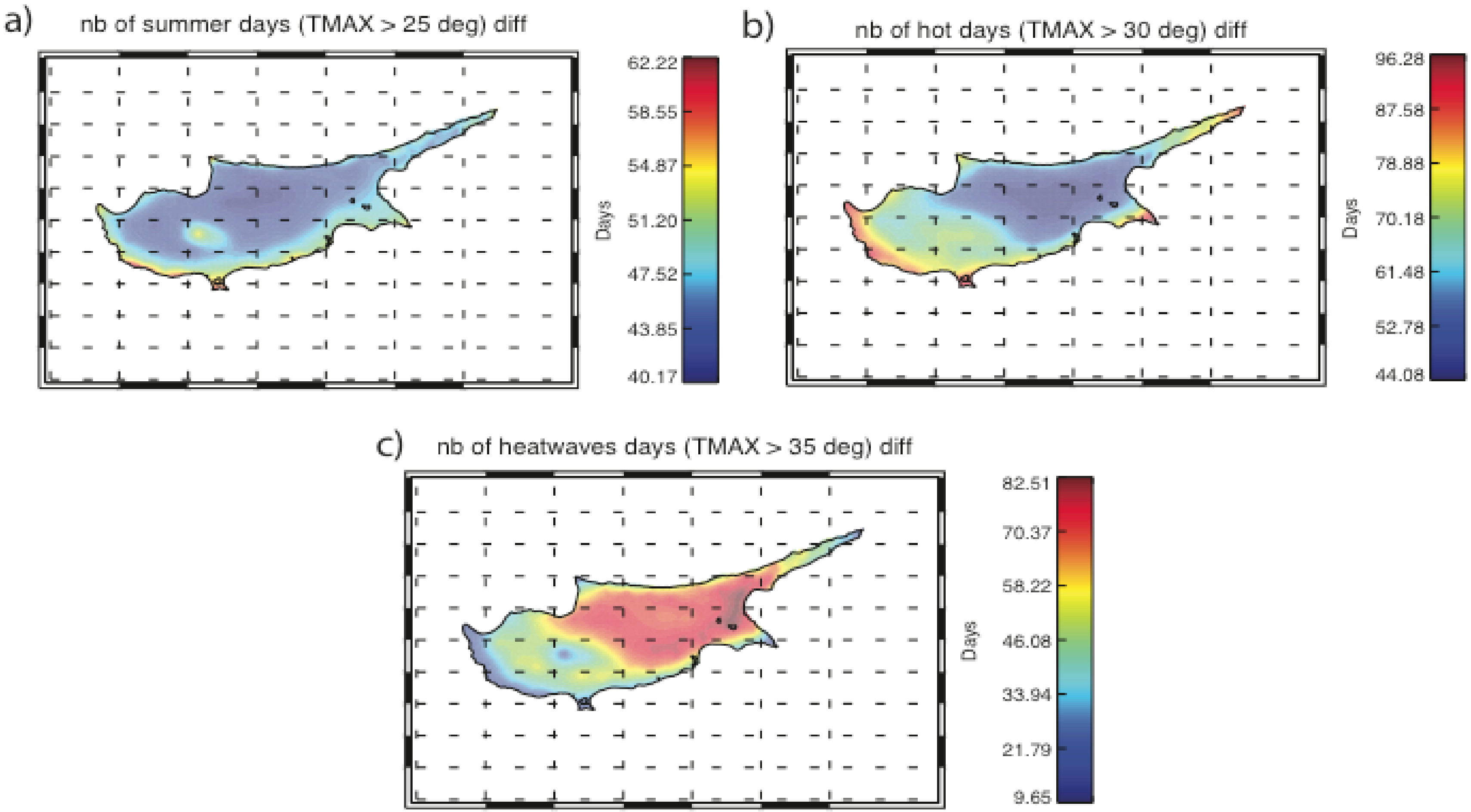
- Again, increases everywhere (though somewhat smaller), and again strongest in the summer. Peak in high elevation only for the summer. In the winter, those areas show the smallest decreases, as for 2050.

Changes in Tmin by 2080 in RCP8.5



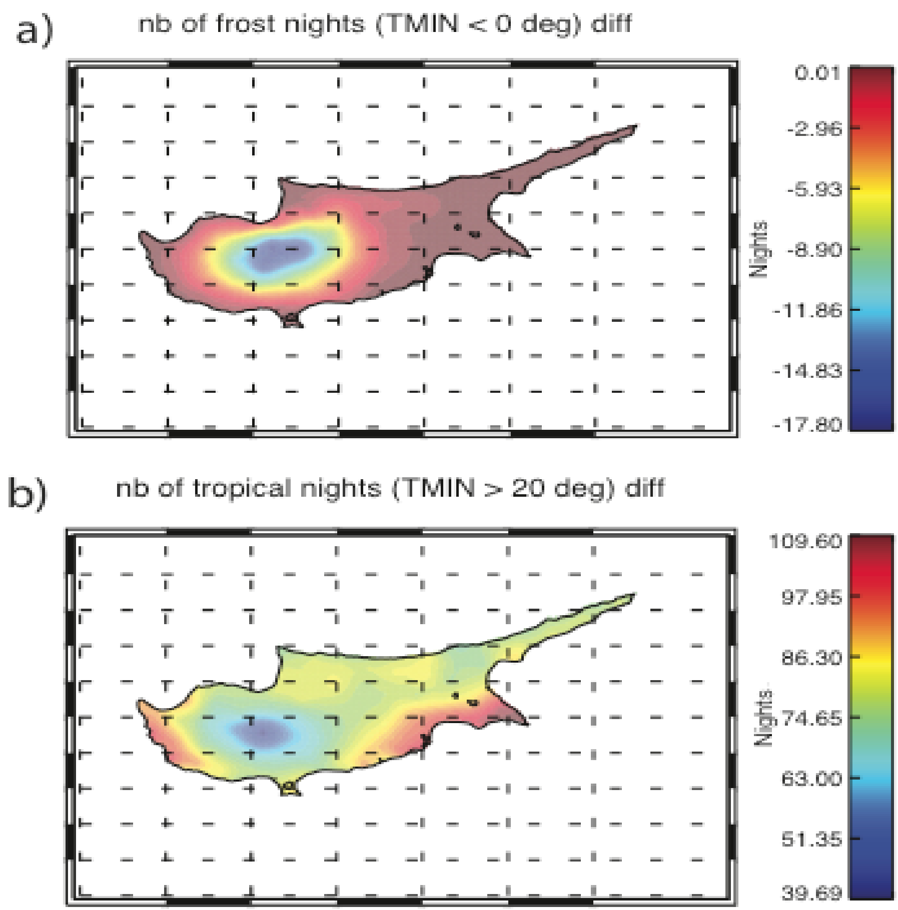
- Stronger increases, largest in high elevation areas in the summer. Pattern similar to that for RCP4.5, except for the fall.

Changes in temperature extremes by 2080 in RCP8.5 (I)



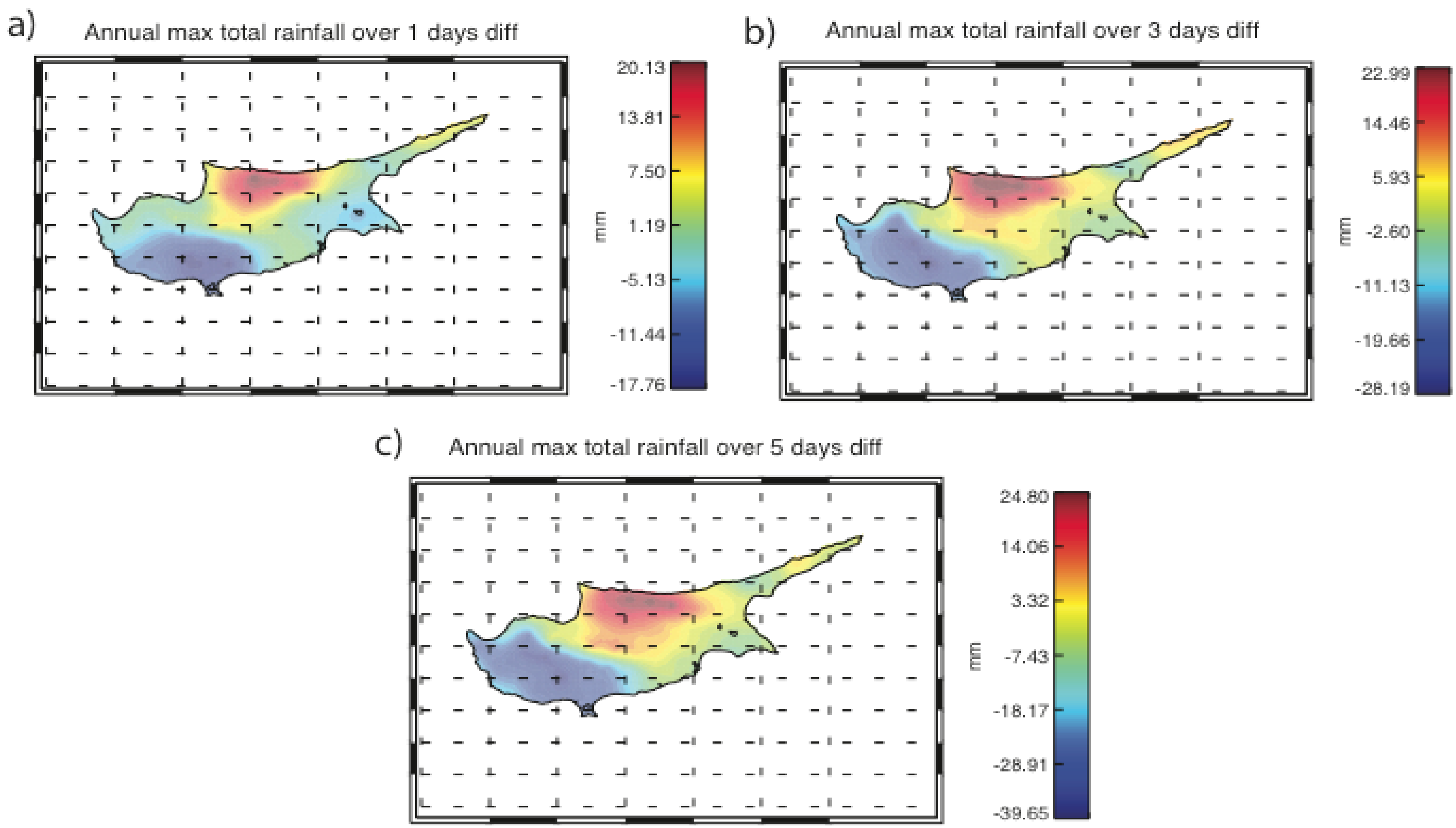
- Drastic increases of all the metrics. Number of heatwaves increases more in the continental lowland and eastern coastal areas.

Changes in temperature extremes by 2080 in RCP8.5 (II)



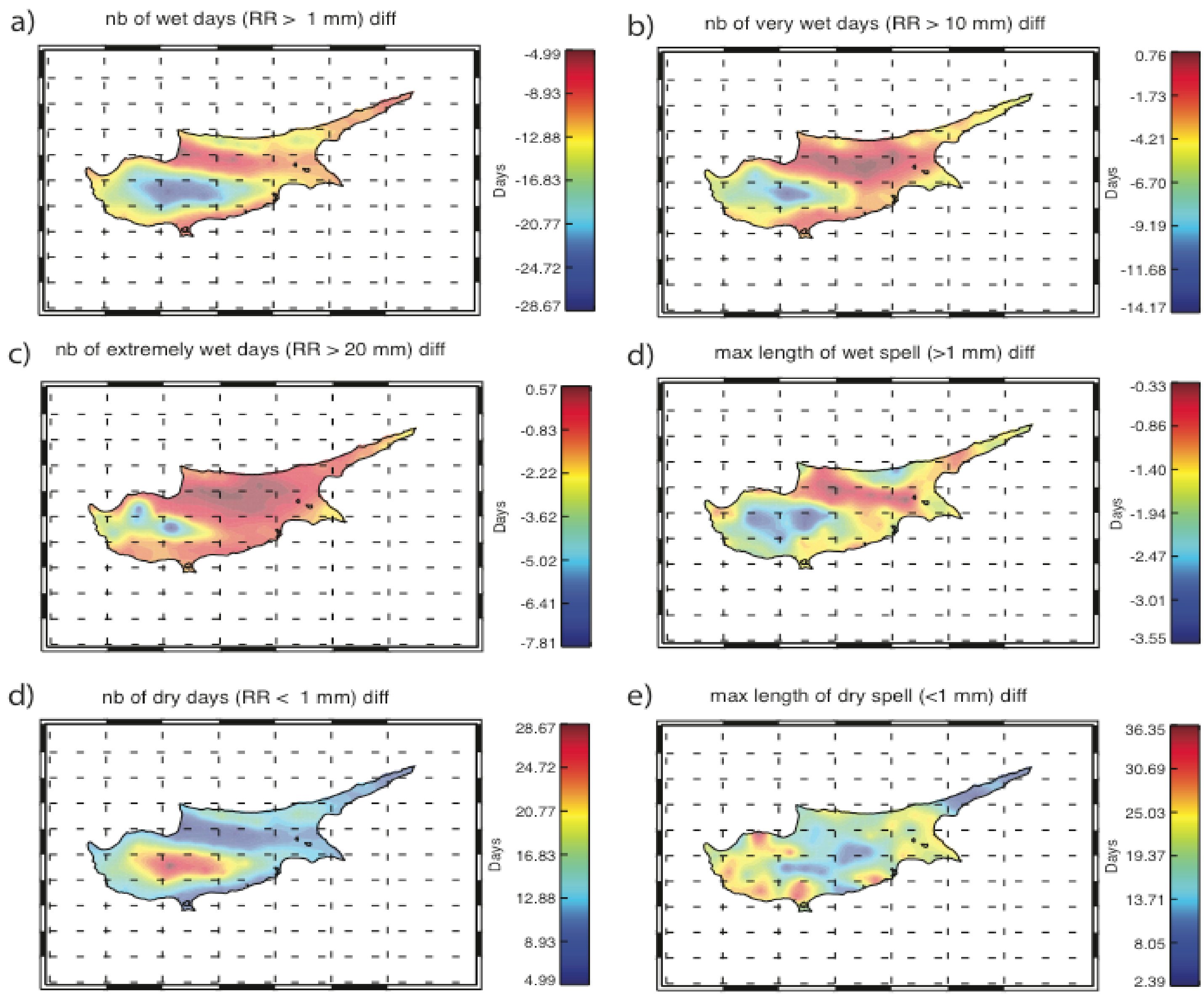
• Frost nights decrease everywhere, but more in the high elevation areas. Tropical nights increase more in some coastal areas, especially in the southeast. Both are consistent with the picture for 2050.

Changes in precipitation extremes by 2080 in RCP8.5 (I)

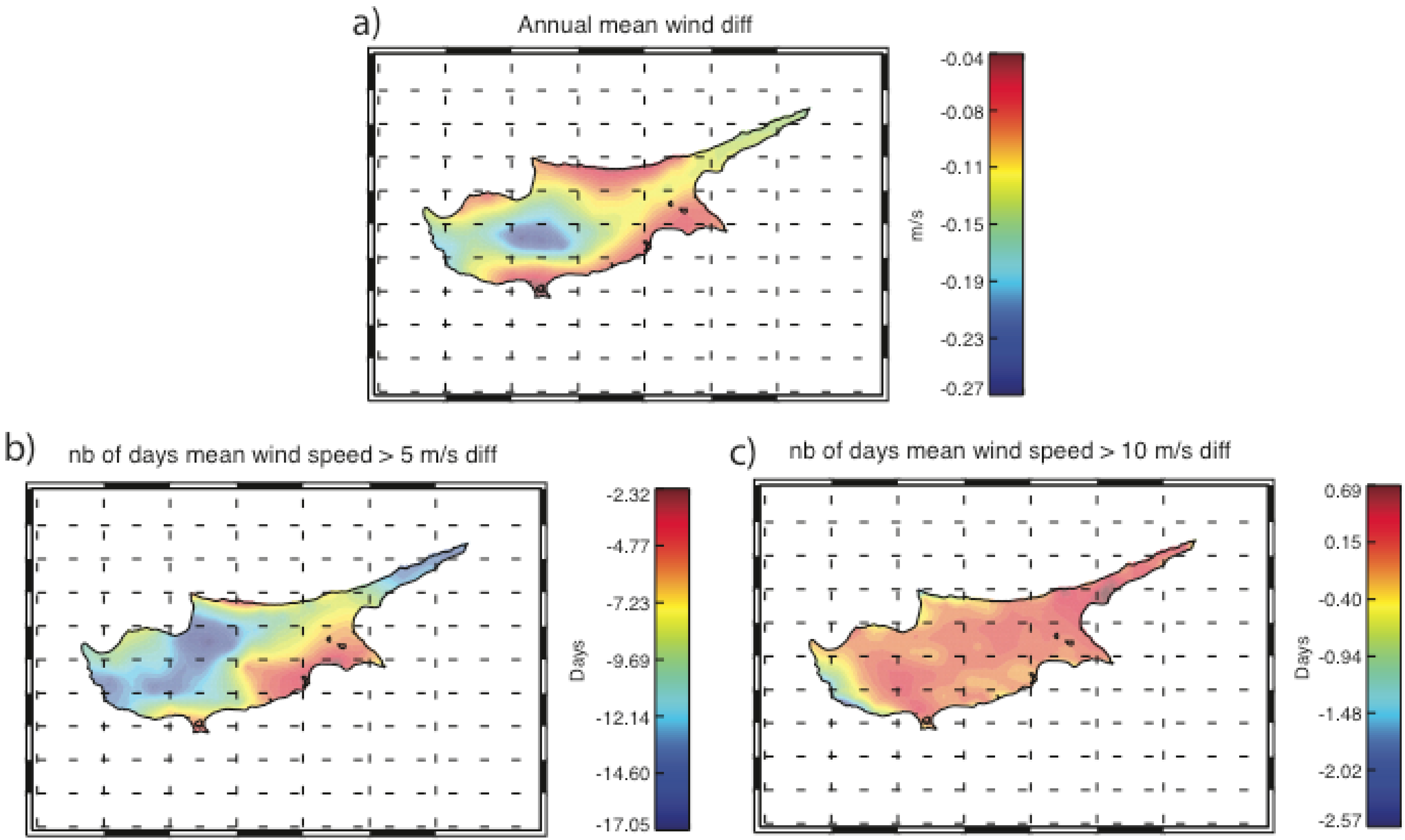


- Tendency for the north+centre to experience more extreme rainfall, while the south+west experience less (somewhat different picture to 2050).

Changes in precipitation extremes by 2080 in RCP8.5 (II)

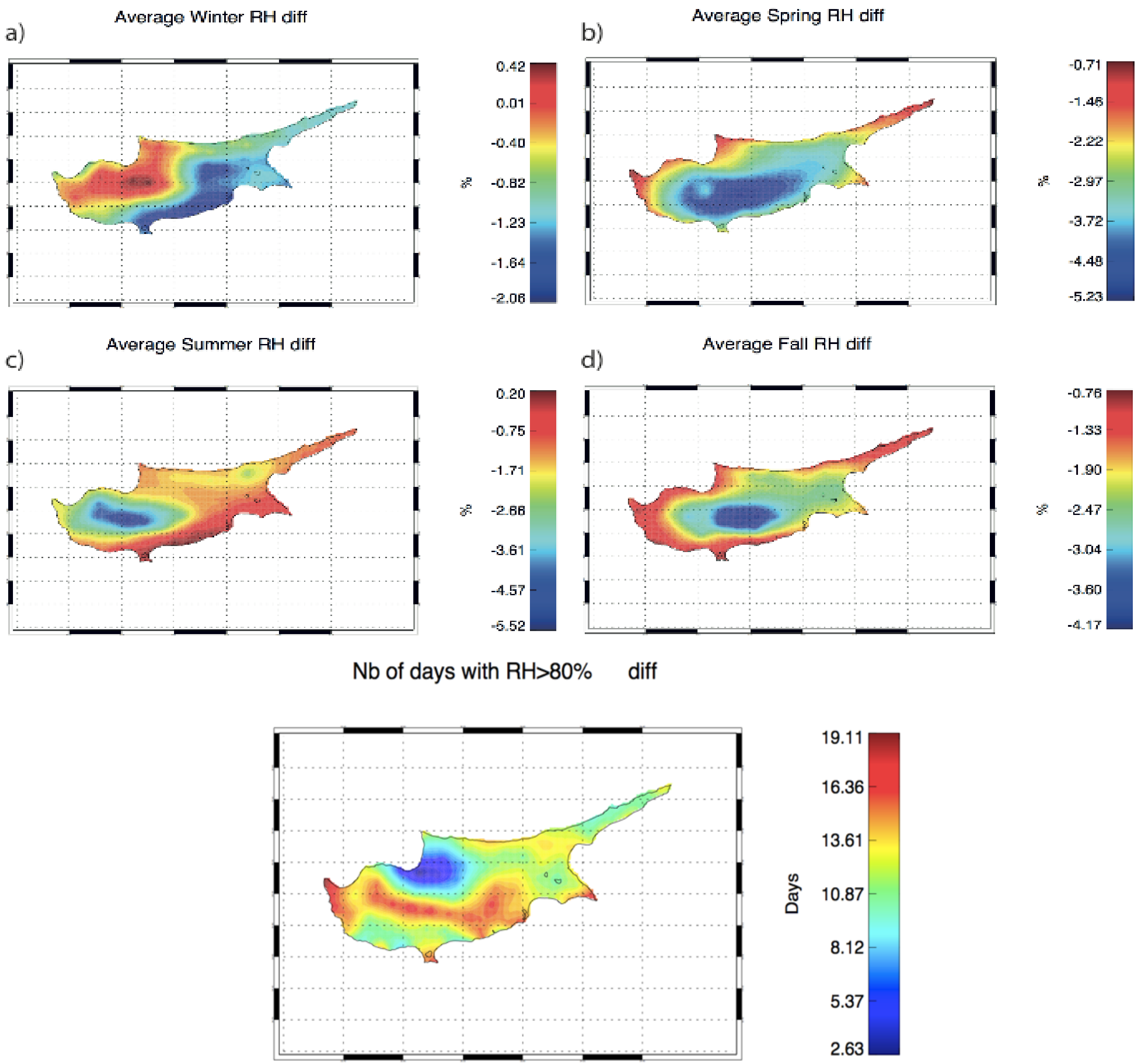


Changes in wind metrics by 2080 in RCP8.5

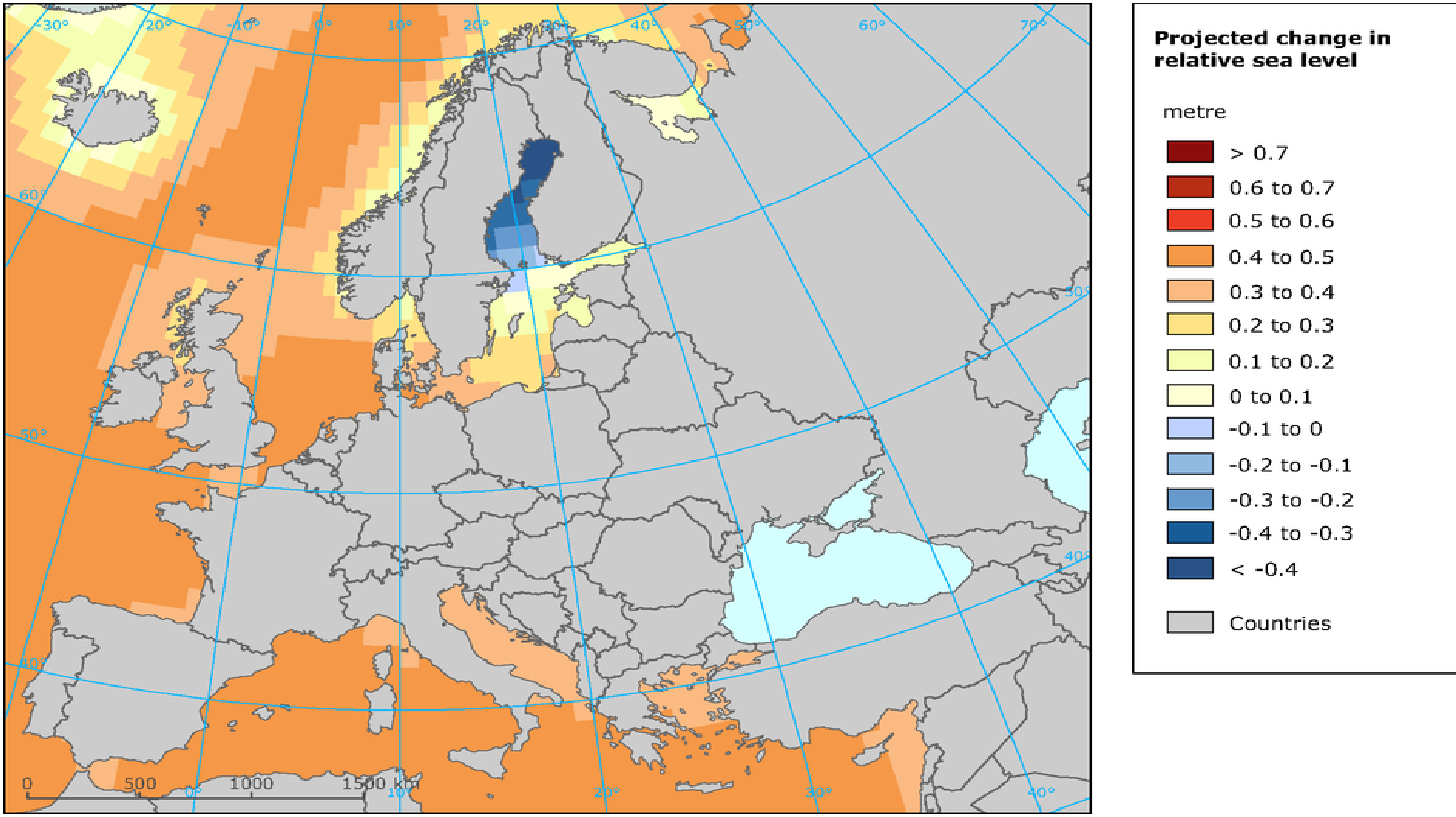


- Mostly minor changes in the winds, though somewhat stronger than for 2050. Tendency for a general decrease.

Changes in relative humidity metrics by 2080 in RCP8.5

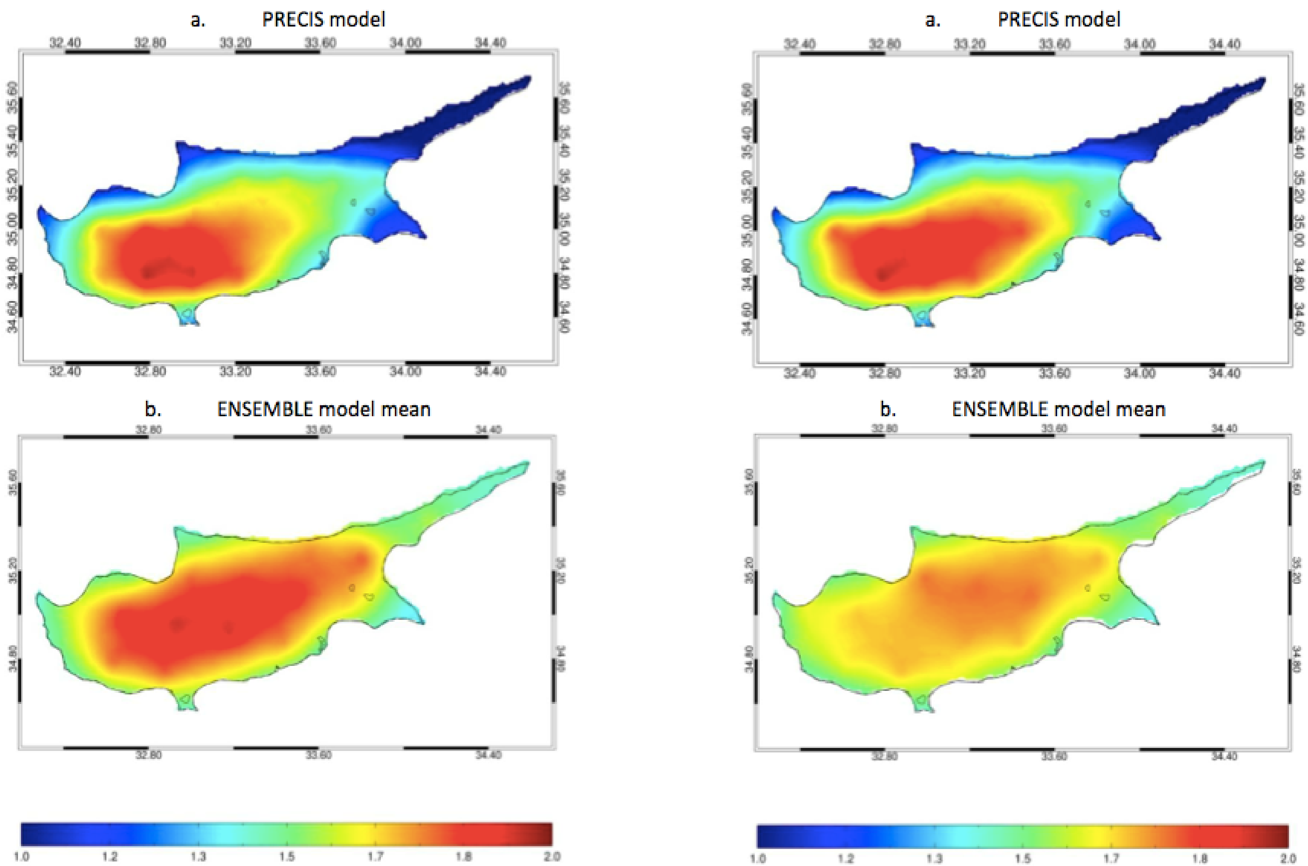


Changes in relative sea level by 2090 in RCP4.5



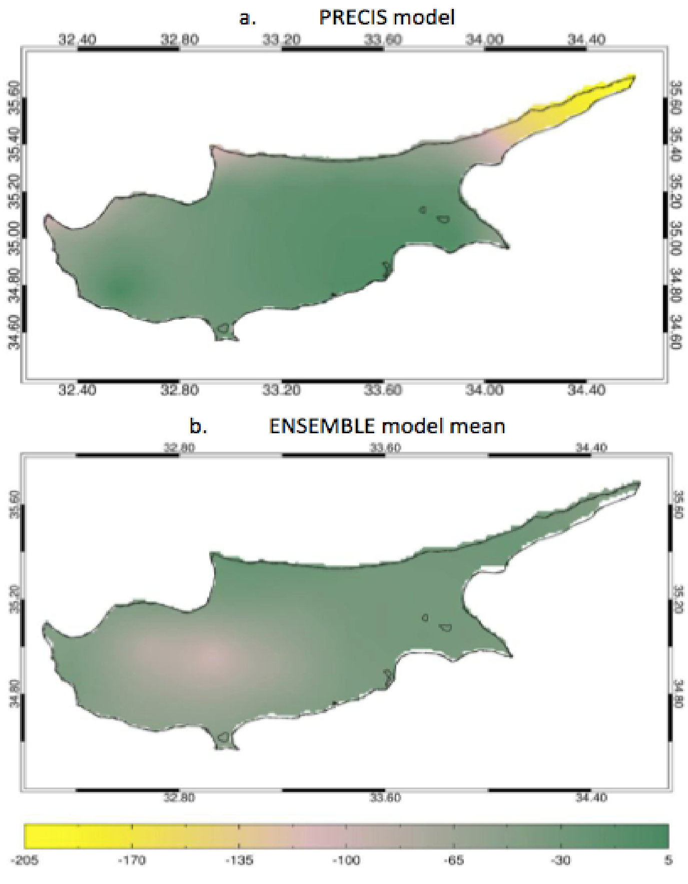
- Generally increases of about 0.4-0.5 m found in the Mediterranean area.

Some key results from CYPADAPT (I)



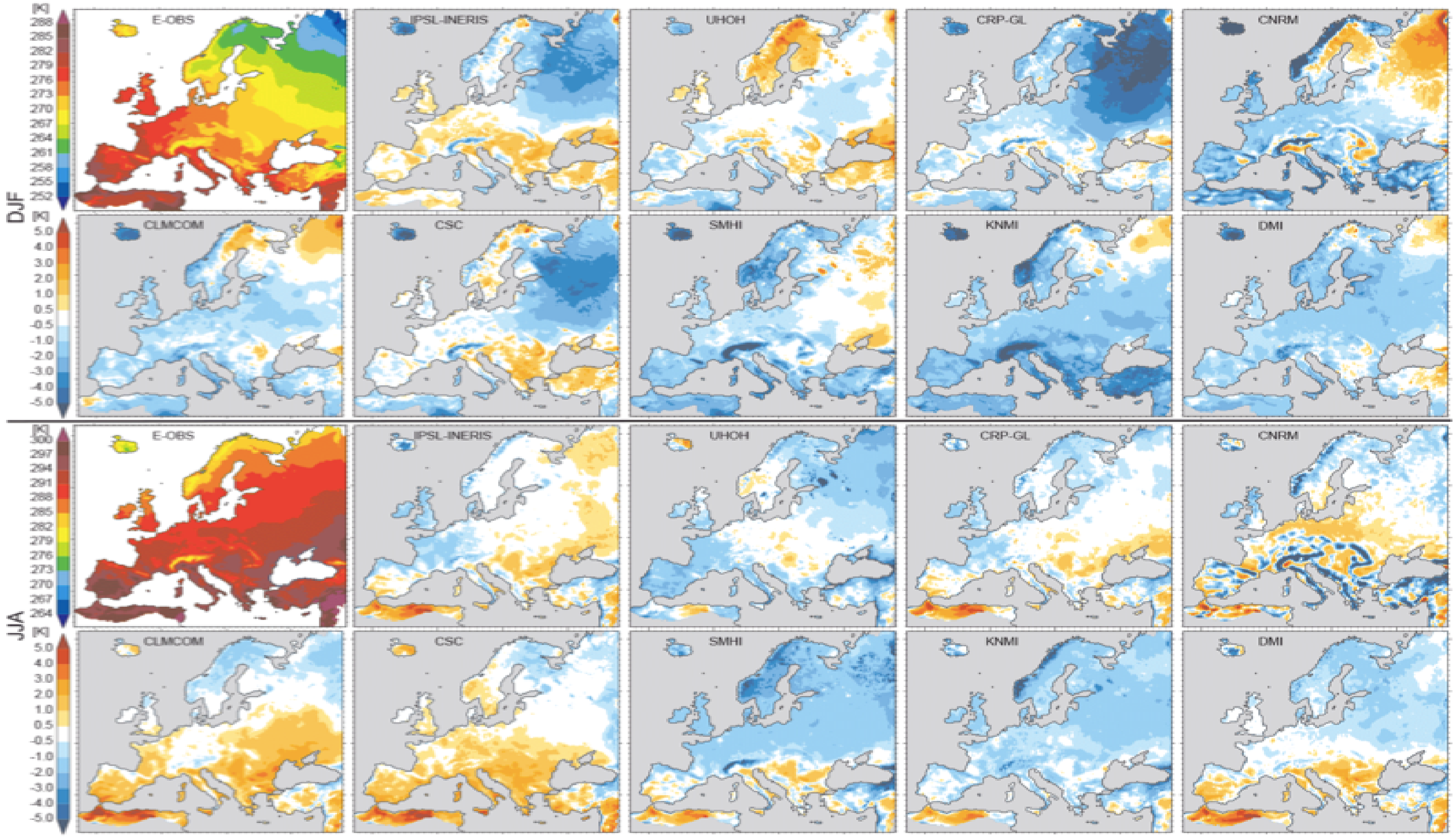
• Changes in average annual maximum (left) and minimum (right) temperature (in degrees Celsius) between the future (2021-2050) and the control period (1961-1990) in the PRECIS and ENSEMBLE models

Some key results from CYPADAPT (II)



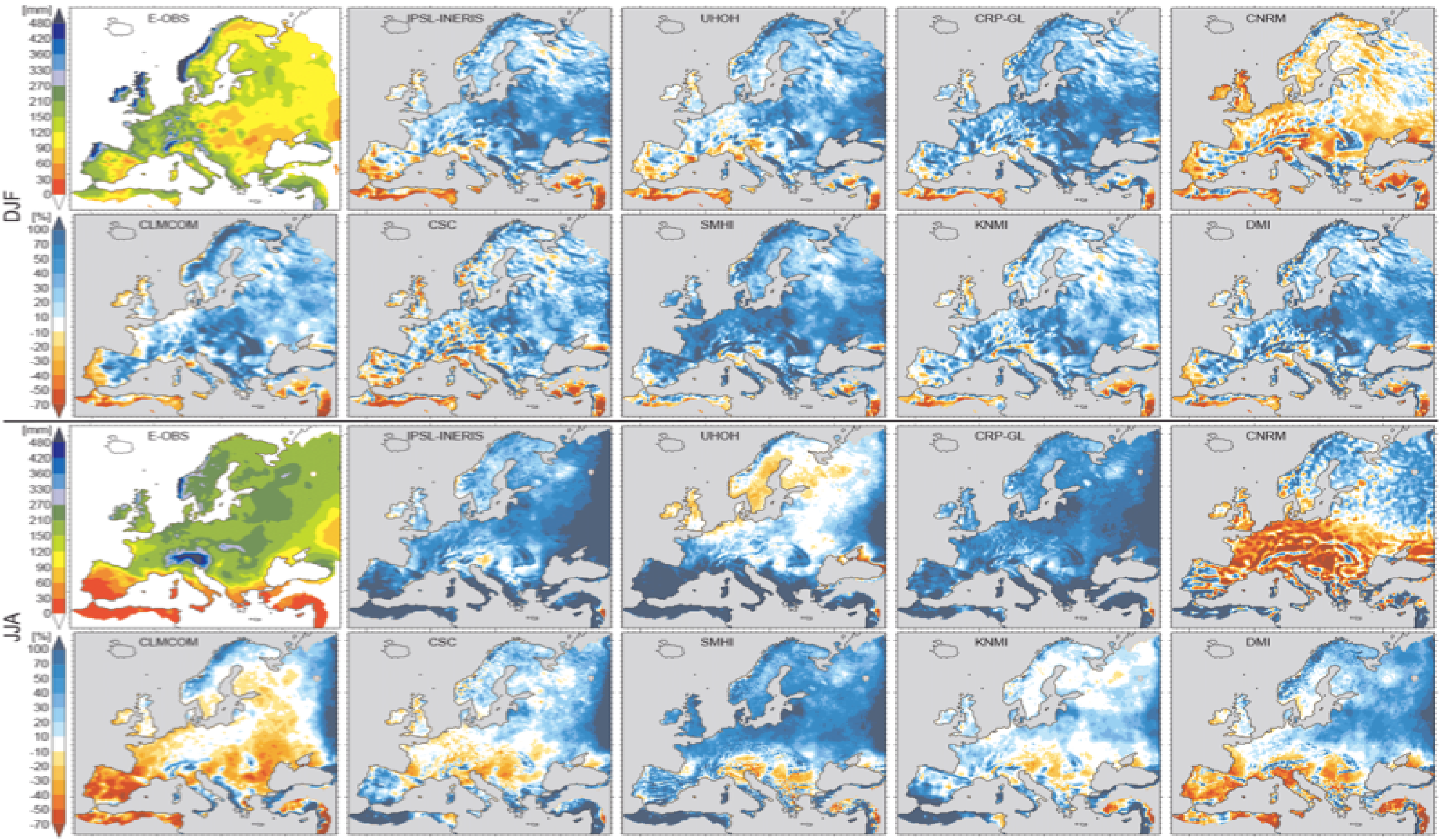
• Changes in annual total precipitation (in mm/year) between the future (2021-2050) and the control period (1961-1990) in the PRECIS and ENSEMBLES models.

Evaluation efforts as part of CORDEX (I)



• Mean seasonal temperature bias (K) for all experiments of the EUR-11 ensemble and the period 1989–2008. Upper rows: winter (DJF), lower rows: summer (JJA). Upper-left panel of each section shows the horizontal pattern of mean seasonal temperature as provided by the E-OBS reference (K).

Evaluation efforts as part of CORDEX (II)



- As previous, but for the mean relative seasonal precipitation bias (%). The upper-left panel of each section shows the horizontal pattern of mean seasonal precipitation as provided by the E-OBS reference (mm month^{-1}).

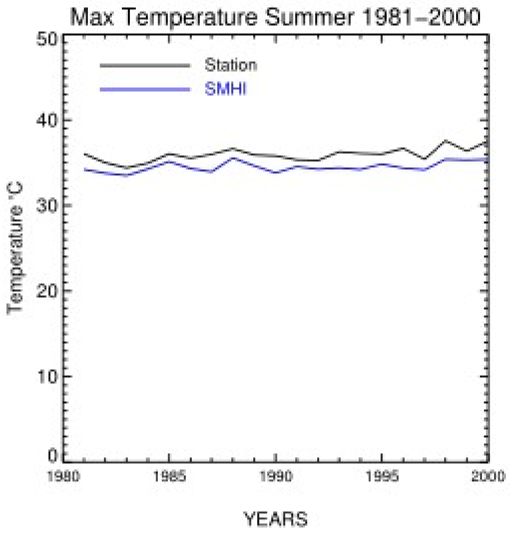
1. Overview of model evaluation results

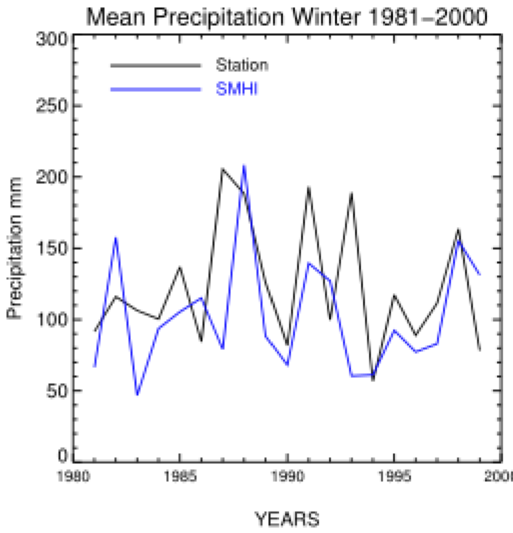
Stations used in the model evaluation

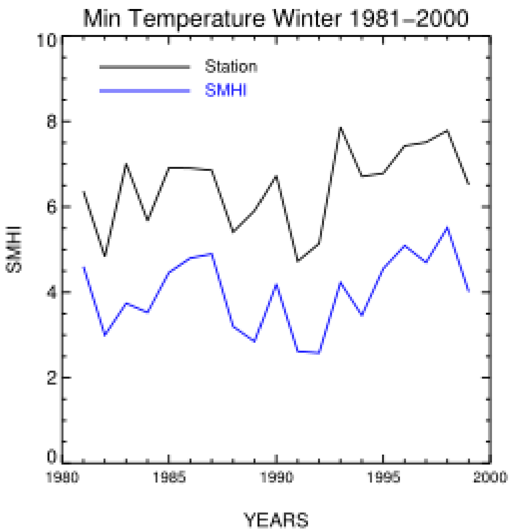
STATION	LATITUDE (N)	LONGITUDE (E)	ALTITUDE (m)
PRODROMOS	34.95	32.83	1423
AMIANTOS	34.93	32.92	1397
PANAGIA	34.92	32.63	871
STAVROS	35.02	32.63	810
SAITTAS	34.86	32.91	641
LEFKARA	34.90	33.29	391
NICOSIA	35.16	33.35	160
LIMASSOL	34.66	33.02	31
LARNACA	34.88	33.63	2

- The stations have been selected to be representative of key parts of the island.

Evaluation for Nicosia

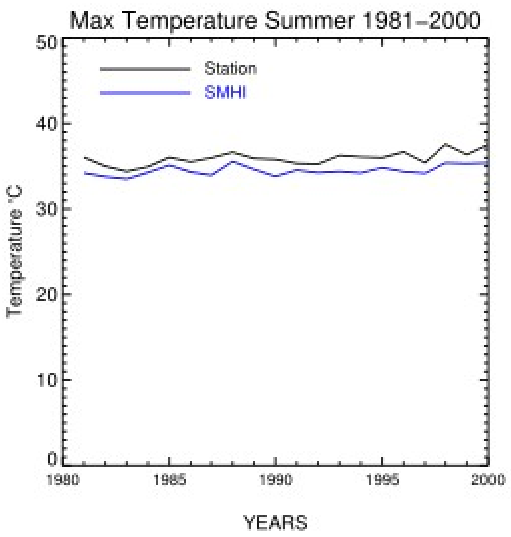


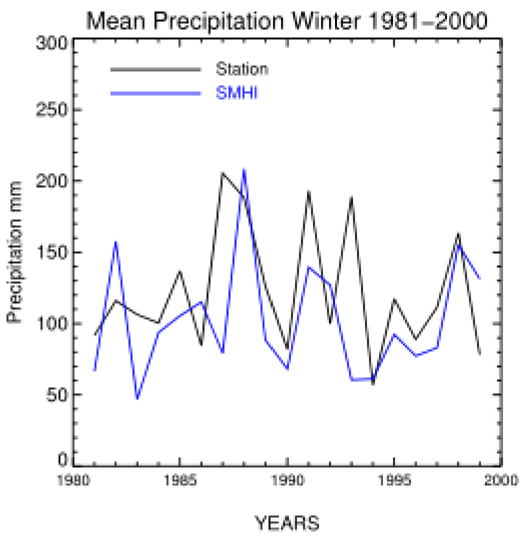


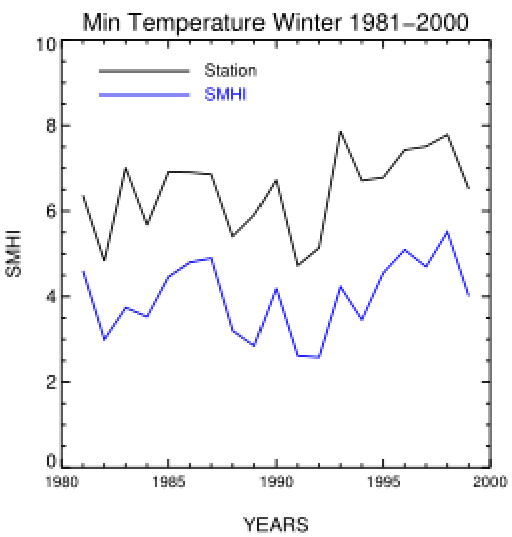


- The stations have been selected to be representative of key parts of the island.

Evaluation for Nicosia







- The stations have been selected to be representative of key parts of the island.

Summary of evaluation results

Tmin	R				SLOPE				INTERCEPT			
		CNRM	ICTP	SMHI		CNRM	ICTP	SMHI		CNRM	ICTP	SMHI
	Amiantos	0.995	0.999	0.992	Amiantos	0.78	0.92	0.74	Amiantos	-5.27	0.47	0.39
	Larnaca	0.999	0.999	0.999	Larnaca	1.22	0.92	1.01	Larnaca	-5.57	4.81	-0.49
	Lefkara	0.999	0.999	0.997	Lefkara	1.1	1.08	1.11	Lefkara	-4.97	-0.78	-2.04
	Limassol	0.998	0.997	0.998	Limassol	1.27	0.96	1.17	Limassol	-7.91	4.1	-2.5
	Nicosia	0.999	0.998	0.998	Nicosia	1.17	0.99	1.08	Nicosia	-5.05	-1.35	-2.74
	Panagia	0.998	0.998	0.998	Panagia	1.03	0.85	0.78	Panagia	-5.85	0.92	-0.42
	Prodromos	0.997	0.999	0.992	Prodromos	0.82	0.91	0.75	Prodromos	-4.48	1.12	0.75
	Saittas	0.999	0.999	0.994	Saittas	1.09	1.03	0.86	Saittas	-6.4	-0.67	-1.56
	Stavros	0.999	0.998	0.995	Stavros	1	0.91	0.83	Stavros	-3.99	0.48	-0.2
		0.998	0.998	0.996		1.053	0.952	0.926		-5.499	1.011	-0.979

Tmax	R				SLOPE				INTERCEPT			
		CNRM	ICTP	SMHI		CNRM	ICTP	SMHI		CNRM	ICTP	SMHI
	Amiantos	0.998	0.993	0.997	Amiantos	0.94	1.11	0.98	Amiantos	1.93	2.48	1
	Larnaca	0.999	0.999	0.999	Larnaca	1.02	0.85	1.1	Larnaca	0.3	0.24	-3.32
	Lefkara	0.99	0.985	0.989	Lefkara	0.88	1.14	1.03	Lefkara	2.64	-4.27	-3.32
	Limassol	0.999	0.999	0.999	Limassol	1.04	0.82	1.08	Limassol	-1	0.64	-3.33
	Nicosia	0.999	0.999	0.999	Nicosia	0.96	1.11	1.03	Nicosia	1.68	-3.23	-2.59
	Panagia	0.996	0.996	0.995	Panagia	0.97	0.99	1.02	Panagia	3.53	3.65	0.38
	Prodromos	0.998	0.995	0.998	Prodromos	0.95	1.09	0.98	Prodromos	3.26	2.83	1.05
	Saittas	0.999	0.999	0.999	Saittas	0.93	1.08	1	Saittas	-0.21	-3.89	-6.29
	Stavros	1	0.999	0.999	Stavros	0.98	0.94	0.97	Stavros	0.43	2.57	-0.12
		0.998	0.996	0.997		0.963	1.014	1.021		1.396	0.113	-1.838

Precip	R				SLOPE				INTERCEPT			
		CNRM	ICTP	SMHI		CNRM	ICTP	SMHI		CNRM	ICTP	SMHI
	Amiantos	0.972	0.998	0.98	Amiantos	0.54	0.48	1.15	Amiantos	38.41	0.13	28.9
	Larnaca	0.99	0.979	0.955	Larnaca	0.88	1.06	0.72	Larnaca	2.64	8.82	4.53
	Lefkara	0.946	0.997	0.981	Lefkara	0.42	0.65	0.85	Lefkara	18.02	0.19	8.93
	Limassol	0.989	0.986	0.997	Limassol	0.53	1.67	0.52	Limassol	7.05	9.92	-1.11
	Nicosia	0.986	0.997	0.995	Nicosia	0.79	0.69	0.67	Nicosia	10.02	-0.66	-0.73
	Panagia	0.981	0.997	0.997	Panagia	0.47	0.69	1.39	Panagia	18.23	-0.48	7.01
	Prodromos	0.98	0.993	0.986	Prodromos	0.59	0.52	1.42	Prodromos	26.03	-2.15	22.09
	Saittas	0.968	0.991	0.984	Saittas	0.39	0.69	1.69	Saittas	18.79	-4.74	24.02
	Stavros	0.976	0.996	0.995	Stavros	0.42	0.7	1.09	Stavros	20.44	0.05	9.29
		0.976	0.993	0.986		0.559	0.794	1.056		17.737	1.231	11.437

- Generally very good skill in capturing temperature, and satisfactory performance in precipitation (though with substantial overestimates).