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PREDICTION OF CLIMATE CHANGE IMPACTS ON COTTON YIELDS IN GREECE UNDER EIGHT CLIMATIC MODELS USING THE AQUACROP CROP SIMULATION MODEL.

Στυλ κύριου υπότιτλου

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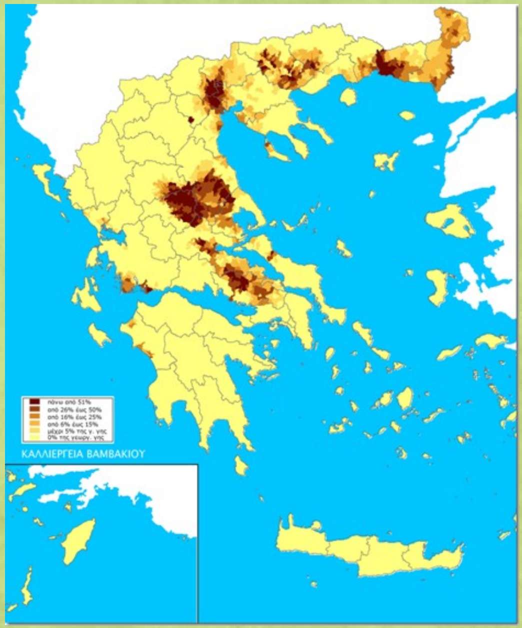
Introduction

- Why Greece?
- IPCC 4th report Southern Europe = vulnerable to climate change
- Why cotton?
- Greece is the largest producer in EU (80% total production)
- Greek Cotton added value is 426 million €
- Goal: integrated view of the future cotton yield



Previous research

- PESETA project (2009) → Mediterranean South Europe +5% to -27%
- Giannakopoulos et al (2009) → C_3 crops -8% to +5% until 2060

For <u>cotton</u> in Greece

- Greek Ministry of Environment (1997) → -29% Thessaly&Macedonia
  +21% Thrace
- Greek Climate Change Study Committee (2011)

increase in Eastern Macedonia- Thrace and Western Macedonia

decline in Central Eastern Greece

Materials and Method

- Study Areas

Alexandroupoli –Eastern Macedonia/Thrace (NE)

Mikra- Western and Central Macedonia (N-NW)

Arta&Agrinio – Western Greece (W)

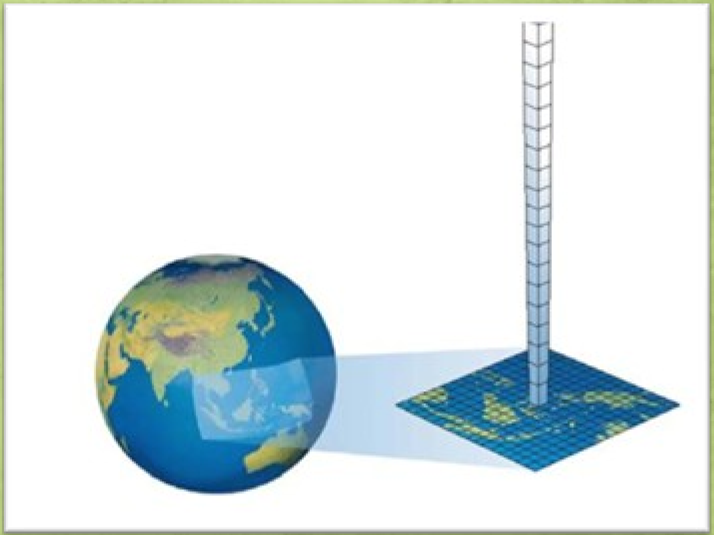
Karditsa&Yliki- Eastern and Central Greece (C-E)

Pyrgos- Western Peloponnese (SW)

Seedcotton yields (tn/h) in the seven study areas for the period 1961-1990

	AGRINIO	ARTA	YLIKI	ALEX/LI	PYRGOS	MIKRA	KARDITSA
mean	1,87	1,96	2,00	1,41	2,24	2,12	2,21
Standard error	±0,06	±0,05	±0,06	±0,06	±0,06	±0,04	±0,06

Climate scenario and models



- Emission Scenario A1B IPCC (2001)
- **CO_2** 359ppm (1990) 532ppm(2050) 714ppm(2100)
- **Temp** +2˚C (2050) +4˚C (2100)
- **Precipitation** -10% (2050) -25% (2100)
- **Climate Models** derived from the ENSEMBLES project
- HadRM3
- C4I
- REMO-MPI
- ETHZ
- CNRM
- DMI-HIRHAM
- KNMI
- SMHI
- *Max&min Temperature, Relative humidity, Wind speed, Solar irradiance, Precipitation*

Crop simulation model

- **AquaCrop** is a crop water productivity model developed by the Land and Water Division of the Food and Agricultural Organisation (FAO)

Basic Components

- the climate, with its thermal regime, rainfall, evaporative demand and carbon dioxide concentration;
- the crop, with its development, growth and yield processes;
- the soil, with its water (and salt) balance;
- the management, with practices including irrigation, fertilization and mulching.

- **Simulation of cotton yield** with the use of AquaCrop
  Farahani et al, 2009; Garcia-Vila et al, 2009; Hussein et al, 2011 etc.
- AquaCrop simulations respond to changes in **CO_2 concentration** (Vanuytrecht et al., 2011)

- **Atmosphere**

Daily minimum-maximum air temperature, rainfall, ETo, CO_2 annual concentration

- **Crop**

Phenology, canopy cover, rooting depth, biomass production, harvestable yield, reduction of the canopy expansion rate, acceleration of senescence, closure of stomata, planting/sowing data, thermal based on Growing Degree Days (GDD)

- **Soil**

hydraulic conductivity at saturation, volumetric water content at saturation, field capacity, wilting point

- **Field Management**

- **Irrigation management**

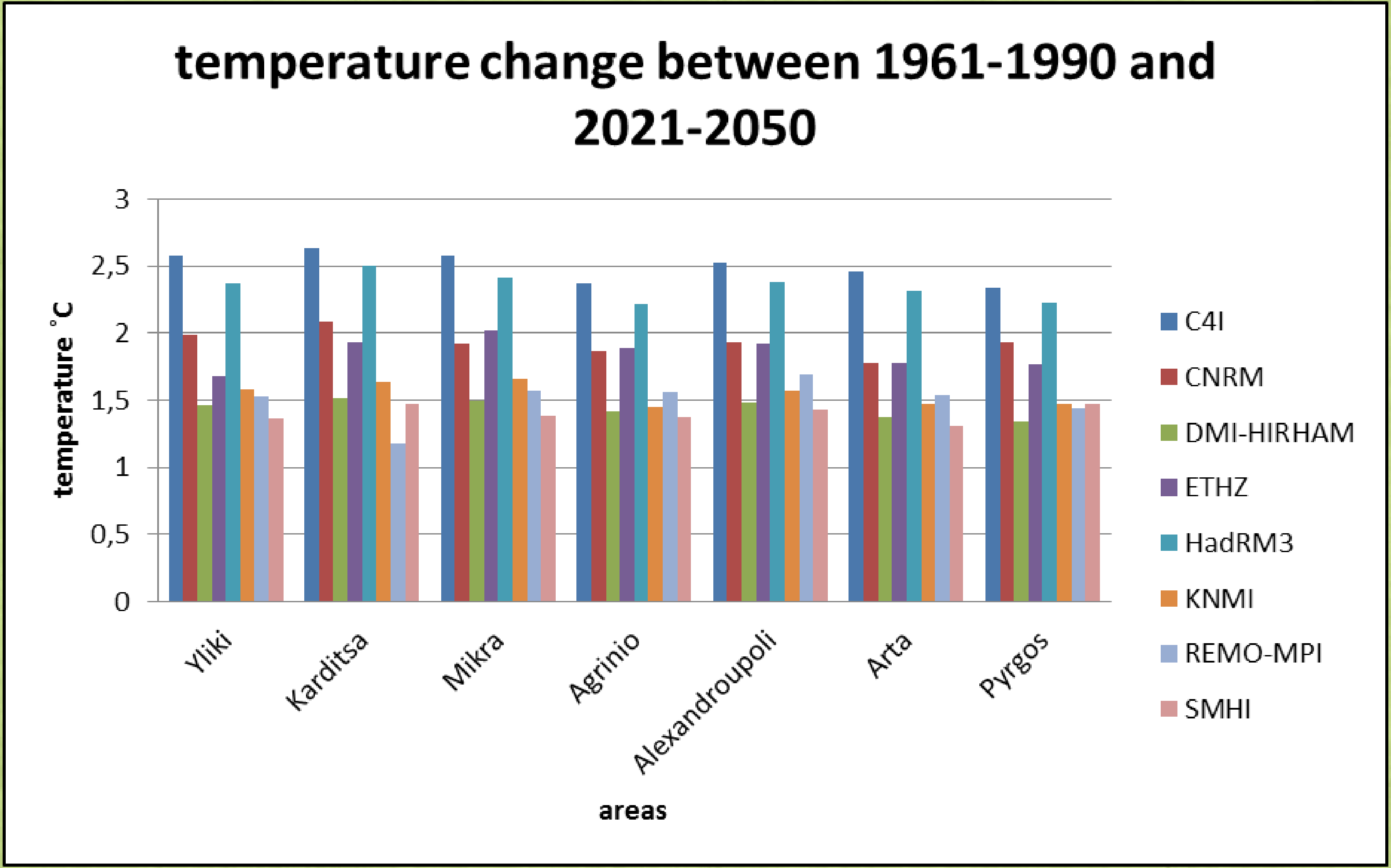
Type: drip irrigation, Fixed time

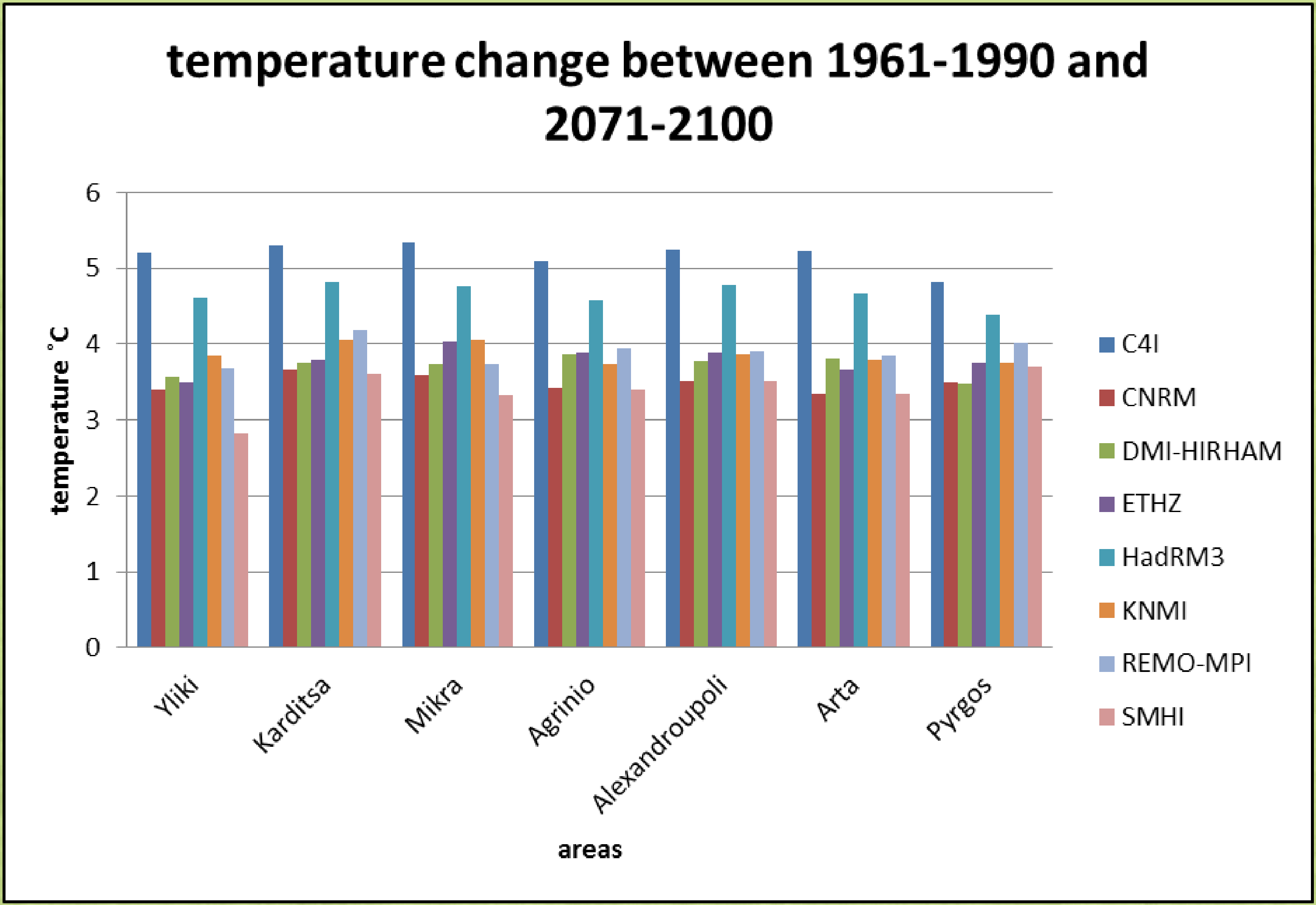
Calibration and validation

Filed experiment Karditsa from 2005 to 2007

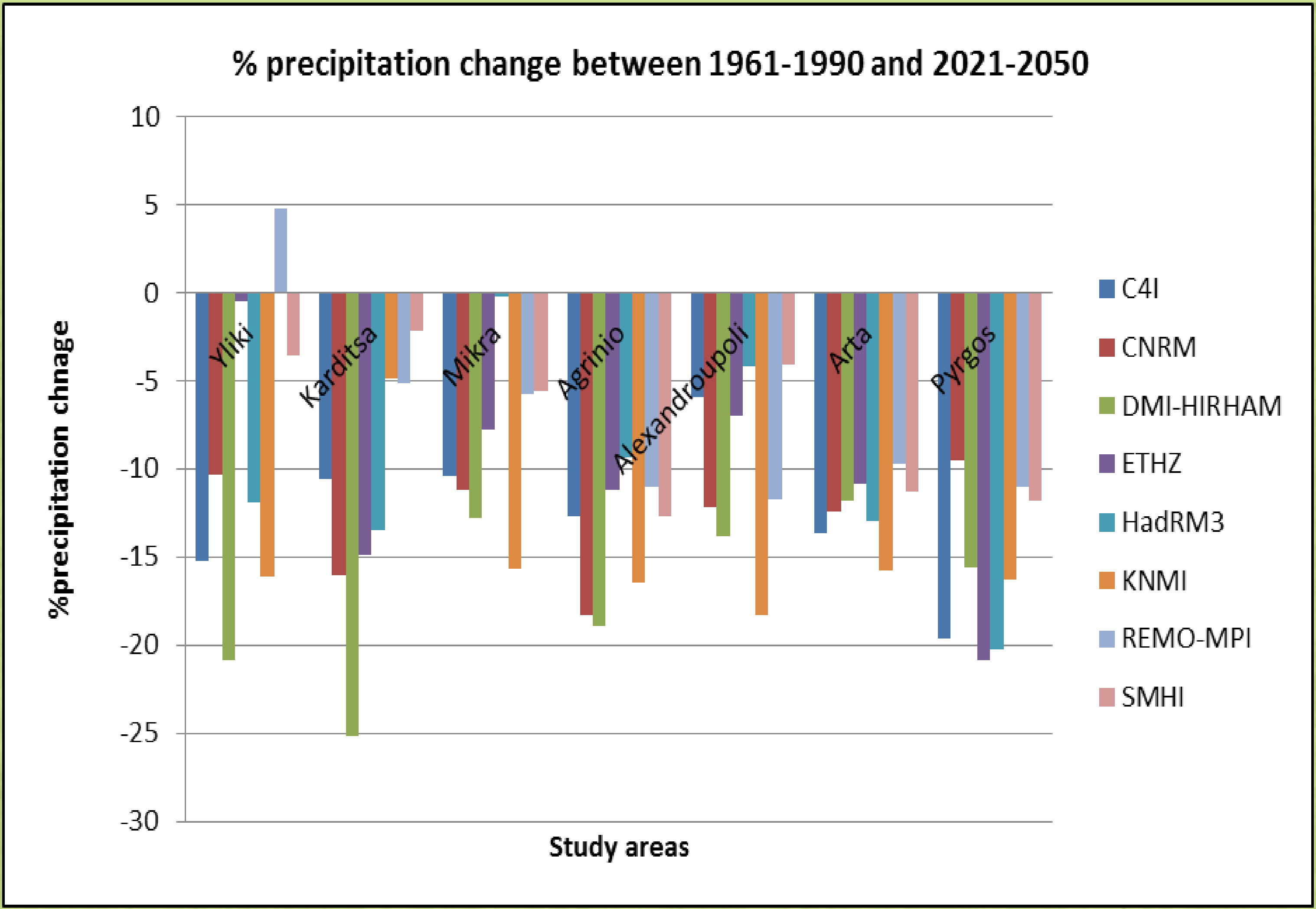
		Years	
Crop characteristics	2005	2006	2007
Yield (tn/ha)			
Observed	4.05	3.65	2.97
Simulated	4.02	3.67	3.26
RMSE		0.17	
d		0.94	
Biomass (tn/ha)			
Observed	14.09	12.85	12.10
Simulated	14.25	12.86	11.20
RMSE		0.49	
d		0.93	

Future projections of some climatic parameters





temperature change between 1961-1990 and 2071-2100
6
5
4
3
2
1
0
temperature °C
Yliki
Karditsa
Mikra
Agrinio
Alexandroupoli
Arta
Pyrgos
areas
C4I
CNRM
DMI-HIRHAM
ETHZ
HadRM3
KNMI
REMO-MPI
SMHI


% precipitation change between 1961-1990 and 2021-2050
10
5
0
-5
-10
-15
-20
-25
-30
%precipitation chnage
Yliki
Karditsa
Mikra
Agrinio
Alexandroupoli
Arta
Pyrgos
Study areas
C4I
CNRM
DMI-HIRHAM
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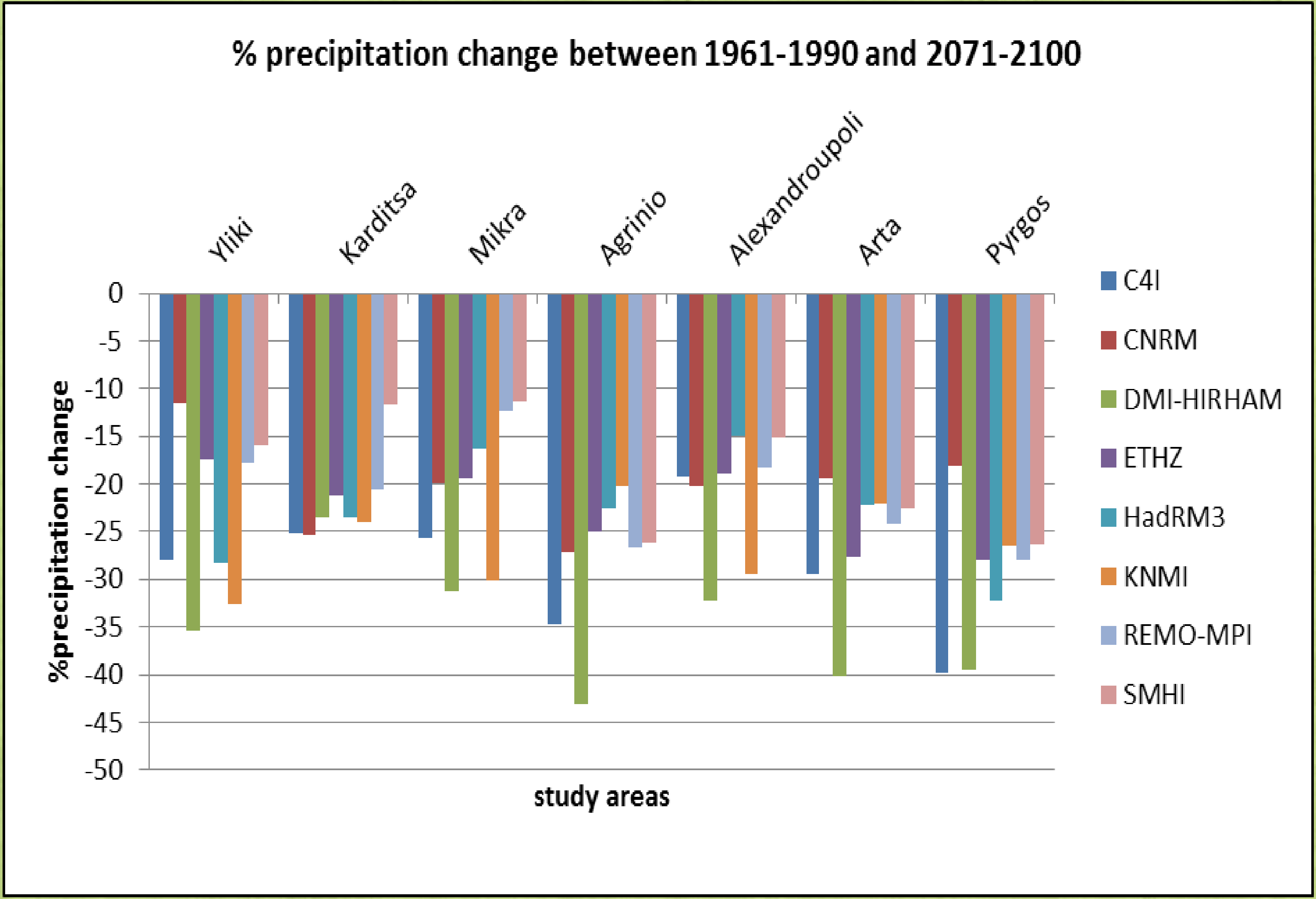

% precipitation change between 1961-1990 and 2071-2100
Yliki
Karditsa
Mikra
Agrinio
Alexandroupoli
Arta
Pyrgos
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
%precipitation change
study areas
C4I
CNRM
DMI-HIRHAM
ETHZ
HadRM3
KNMI
REMO-MPI
SMHI

Cotton yield response to climate change

	Agrinio		Alex/lis		Arta		Karditsa		Mikra		Pyrgos		Yliki	
	1961-1990	1961-1990	1961-1990	1961-1990	1961-1990	1961-1990	1961-1990	1961-1990	1961-1990	1961-1990	1961-1990	1961-1990	1961-1990	1961-1990
	2021-2050	2071-2100	2021-2050	2071-2100	2021-2050	2071-2100	2021-2050	2071-2100	2021-2050	2071-2100	2021-2050	2071-2100	2021-2050	2071-2100
HadRM3	-3.48	-8.71	-137.81	-109.41	12.38	36.49	47.19	19.99	-30.14	-69.66	-24.03	-63.75	-31.35	-102.88
C4I	-0.54	22.56	27.26	-23.84	16.8	7.04	3.38	-11.09	8.01	-18.02	7.69	25.52	20.28	9.57
REMO-MPI	na	na	43.75	43.1	45.84	51.19	7.45	31.16	11.63	38.17	25.33	30.75	8.39	32.2
ETHZ	17.14	20.07	72.2	70.39	12.27	18.67	14.86	25.49	36.04	47.9	7.89	17.87	19.37	27.9
CNRM	-21.54	-3.85	76.94	51.51	na	na	-71.27	-8.53	-10.67	-3.51	-0.73	-37.78	49.31	43.28
DMI-HIRHAM	19.22	28.49	-15.5	-5.06	24.08	31.59	-2.75	28.37	-11.56	7.1	4.48	10.18	7.82	19.81
KNMI	8.83	13.58	na	na	6.61	19.77	16.34	24.94	4.4	-4.57	13.32	19.28	21.27	36.58
SMHI	na	na	na	na	na	na	-14.79	46.93	na	na	na	na	35.73	40.5

Assessment of the used climatic models

- Discriminant Analysis is a tool to find a linear combination of features which separates two or more classes of objects or events (case).

- Discriminant functions

$D= v_1 X_1 + v_2X_2 + v_3X_3 + \ldots + v_iX_i+a$

D=discriminant function, v=discriminant coefficient, X=respontent's score for that variable, a=constant , i=number of predictors

The 1st function maximizes the differences between groups on that function (higher value of v)

- the standardized discriminant coefficients are used in assessing the contribution to the discriminant function of each independent variable.

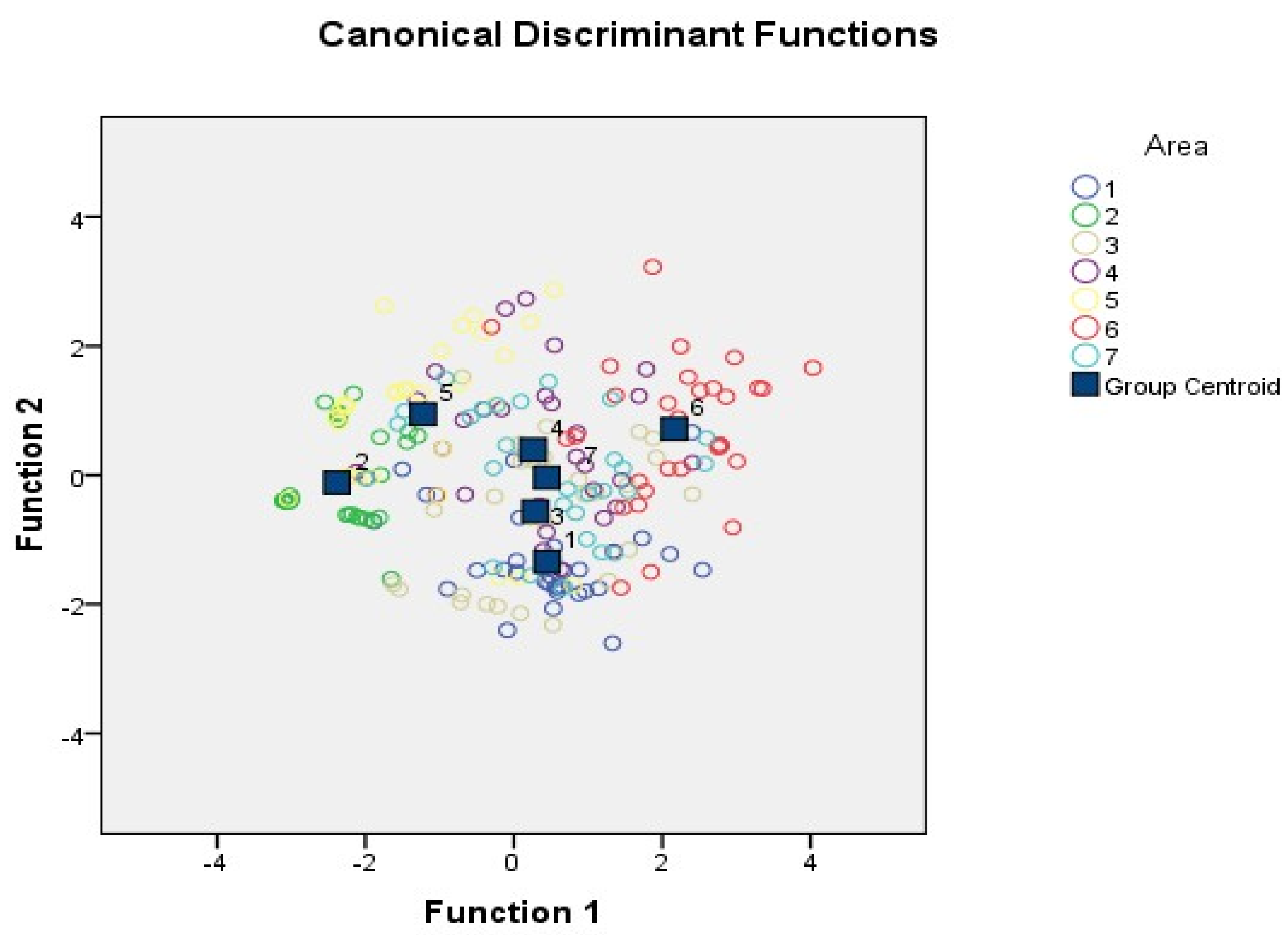
- In the end DF tries to correctly classify the higher percentage of the grouped cases

Standardized Discriminant function coefficients for the three different periods of the functions 1 and 2.

Models	1961-1990		2021-2050		2071-2100	
	Standardized		Standardized		Standardized	
	func 1	func 2	func 1	func 2	func 1	func 2
HadCM3						
C4I	0.569	-0.504	0.556	0.01	0.648	0.018
REMO-MPI	0.328	0.608	0.383	0.821	-0.258	0.38
CNRM	0.176	0.527	-0.36	0.344	0.223	0.221
DMI-HIRHAM	0.454	-0.118	0.456	0.105	0.474	-0.162
KNMI	0.397	0.185	0.383	-0.535	0.483	-0.584
SMHI			0.598	-0.24	0.187	0.869
ETHZ	0.526	0.161				

1961-1990 Function 1 explained 65.6% of the simulated cotton yields variance
2021-2020 Function 1 explained 59.7% of the simulated cotton yields variance
2071-2100 Function 1 explained 53.0% of the simulated cotton yields variance

Plot of the first two discriminant functions for the simulated cotton yield under 7 different areas during the period 1961-1990.
1: Agrinio, 2: Alexandroupoli, 3: Arta, 4: Karditsa, 5: Mikra, 6: Pyrgos, 7: Yliki.



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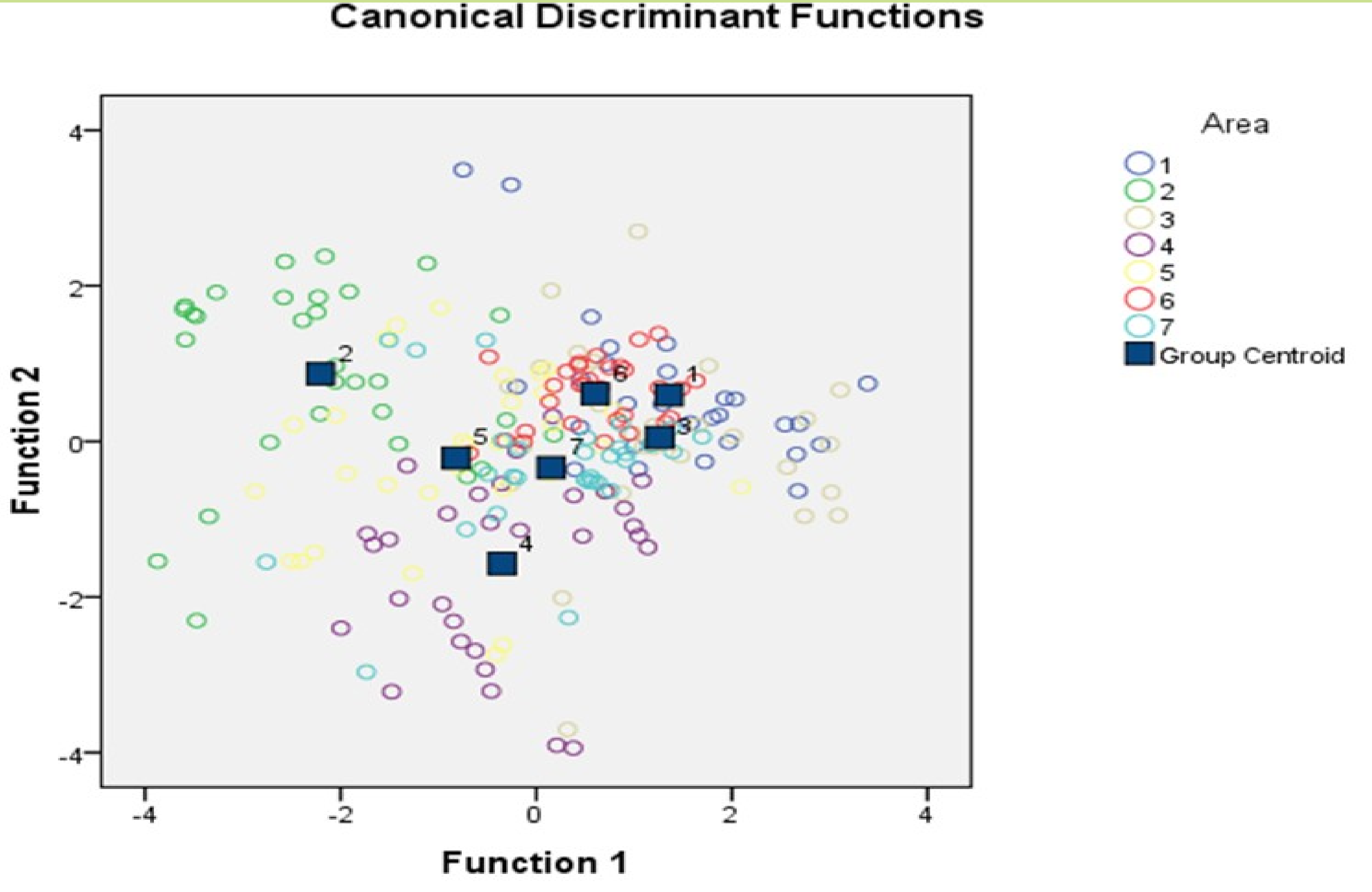
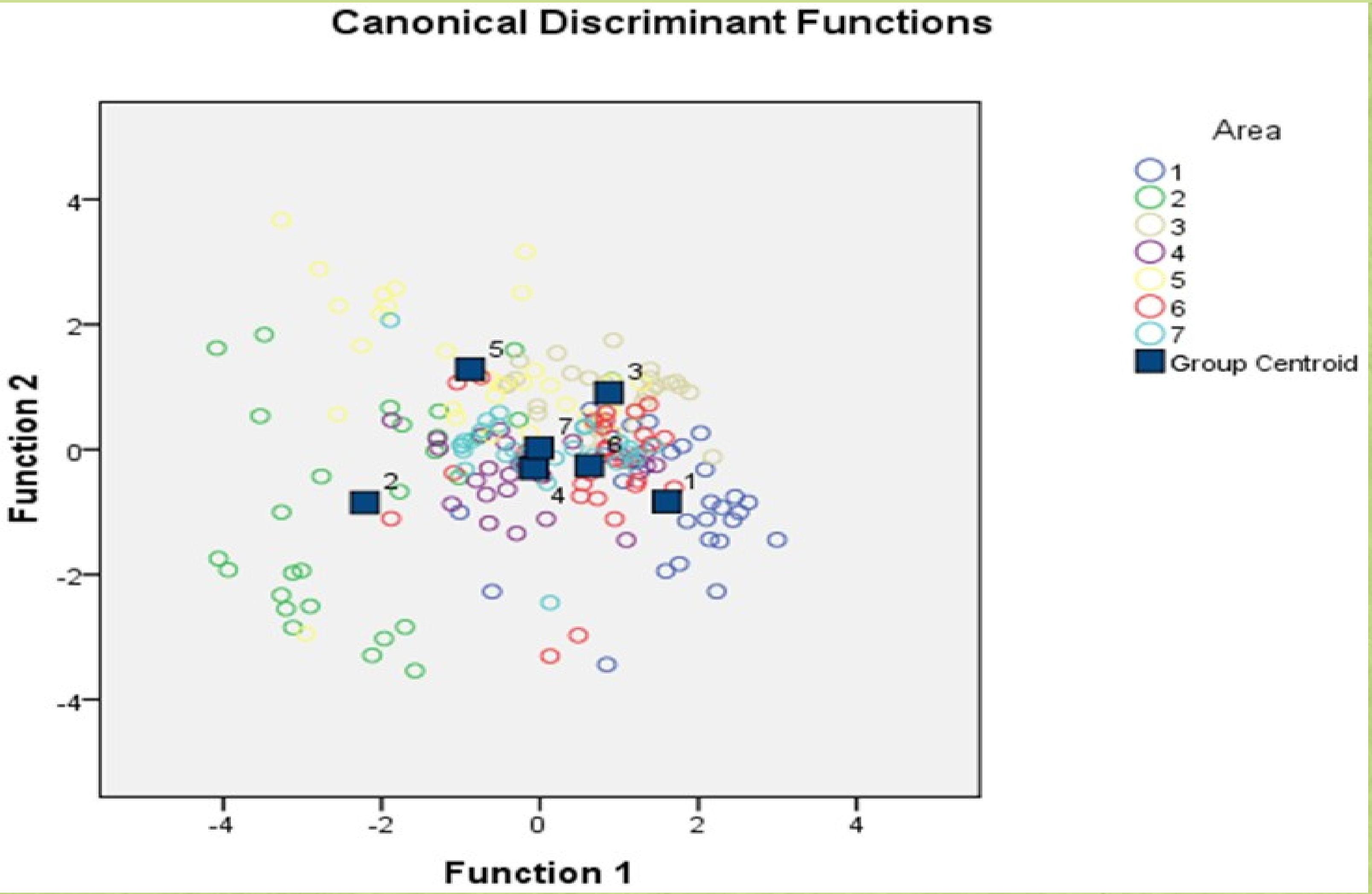


Plot of the first two discriminant functions for the simulated cotton yield under 7 different areas during the period 2071-2099. 1: Agrinio, 2: Alexandroupoli, 3: Arta, 4: Karditsa, 5: Mikra, 6: Pyrgos, 7: Yliki.



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Comparison of seedcotton maximum and minimum yield change in the seven study areas during 2021-2050 as percentage of the reference period 1961-1990 according to the climate models C4I and DMI

Comparison 2021-2050 and 1961-1990

- Arta, Pyrgos and Agrinio (Western Greece) and Yliki (Central Greece) will be more favoured
- Arta (increases from 16.8 to 24.08%)
- Agrinio (-0.54 to 20%)
- Uncertainty highest in Alexandroupolis (-15.5 to 27.3%)

Lower in Karditsa and Mikra (-2.75 to 3.4% and -11.56 to 8% respectively)

Comparison of seedcotton maximum and minimum yield change in the seven study areas during 2071-2100 as percentage of the reference period 1961-1990 according to the climate models C4I and DMI

Comparison 2071-2100 and 1961-1990

- Arta, Agrinio and Pyrgos will also be more favoured during 2071-2100 (predicted increases 7.04 to 31.59%, 22.56 to 28.5%, and 6 to 19.3% respectively)
- The most negative impacts of climate change on seedcotton yields will be observed in Alexandroupolis (-5 to -23.8%)
- Mikra, Karditsa, and Yliki exhibited a high range of yield fluctuations (-28.3 to 16.7%, -15 to 30.3% and -13.5 to 13% respectively)

Conclusions

- The models C4I and DMI were considered as most reliable for discriminating cotton yields during 1961-1990, 2021-2050 and 2071-2100
- Positive impacts of climate change on seedcotton yields in the areas of Western Greece (Agrinio, Arta, Pyrgos), and negative impacts or great fluctuations in the other areas (Northern and Central Greece).
- The magnitude of the changes in the two periods (2021-2050 and 2071-2100) in respect to the reference period of 1961-1990 did not show a definite trend, but changed in the different areas of study
- Uncertainties: need more reliable crop data from more areas for calibration and validation of AquaCrop

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επένδυση στην κοινωνία της γνώσης
ΥΠΟΥΡΓΕΙΟ ΠΑΙΔΕΙΑΣ & ΘΡΗΣΚΕΥΜΑΤΩΝ, ΠΟΛΙΤΙΣΜΟΥ & ΑΘΛΗΤΙΣΜΟΥ
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Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

ΓΕΩΠΟΝΙΚΟ **ΠΑΝΕΠΙΣΤΗΜΙΟ** ΑΘΗΝΩΝ **AGRICULTURAL** UNIVERSITY **OF ATHENS**

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