CLIMATE CHANGES IN EASTERN MEDITERRANEAN

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WORKSHOP

Climate Change Impacts on Mediterranean Plant Diversity

25-28 September 2007, MAICH, Crete

Contents

- Overview of climatic changes
- Trends in present climate of Greece
- Future climatic changes in Eastern Mediterranean
- Input for SEMCLIMED experiments
- Conclusions

...ate ...

Na...

- Sun ...uctua...
- Volcanic erup...
- Internal oscillations of the climatic system

...genic ...ons

- ... land use
- ...ed urban emiss...
- Increased aerosol emissions

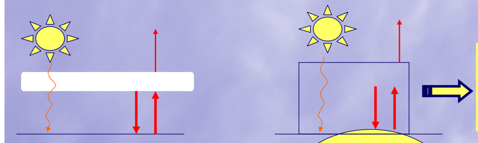
Sulphate and aerosol emissions: cooling 0.5...

deforestation, urbanization: urban heat island

Enhanced greenhouse effect, ozone hole

Yet unclear contribution to the greenhouse effect enhancement

What is the greenhouse phenomenon ?



Global temperature= 15ºC

Instead of -18 ºC

Green... water vapor, CO_2, methane, nitrous oxide, Fluorinated gases

Burning of fossil fuels (coal, oil, natural gas)

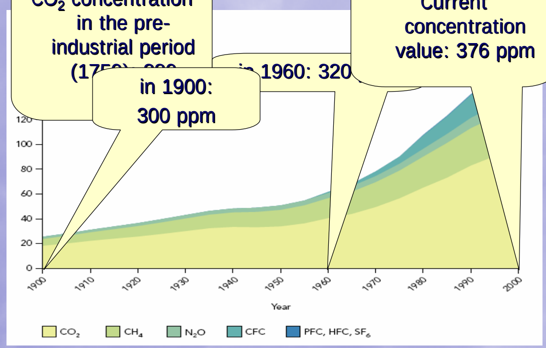
Waste landfill, cattle breeding

Leakage from air conditioners and refrigerators

Increase of greenhouse gas emissions

Enhancement of natural greenhouse effect

What is happening today?



CO_2 concentration in the pre-industrial period (1750): 280 ...

in 1900: 300 ppm

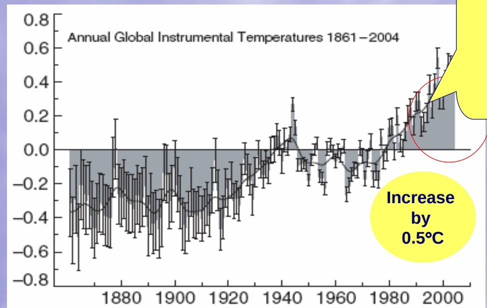
in 1960: 320 ...

Current concentration value: 376 ppm

Source: IPCC, 2001

Is there global warming today?

Deviations of mean global air temperature from the corresponding mean value during the period 1960-1990



Hottest years:
1998
2002
2003
2004
2001

Increase by 0.5ºC

Source: IPCC, 2001

What will happen in the future?

- Further warming of 0.1°C per decade (if CO_2 concentration stabilizes)
- Increase of global mean temperature from 1.4 °C to 5.8°C by 2100, depending of the CO_2 emissions
- Increase of temperature in Europe from 2°C to 6.3°C

Source: IPCC (2001), EEA (2004)

Clima... models

They solve equations of motion, continuity and thermodynamic equations, describing the atmospheric motion, in grids, at predefined time intervals

... cycle, atmospheric chemistry

- Global Models

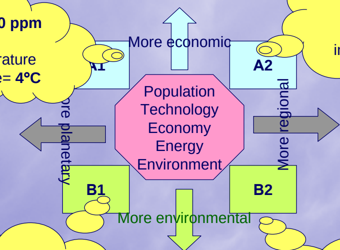
Spatial resolution: 265 km x 300 km

- Regional models

Spatial resolution: 50 km

Regional climate simulation: detailed topography, regional climatic characteristics

Future climatic scenarios



CO_2: 810 ppm
Temperature increase= **4ºC**

CO_2: 715 ppm
Temperature increase= **3.3ºC**

CO_2: 525 ppm
Temperature increase= **2ºC**

CO_2: 562 ppm
Temperature increase= **2.3ºC**

Source:
IPCC (2001)

What is the period of future predictions?

- 2070-2100

- End of century
- Allowing study of long range impacts and implementation of measures
- Solving computer problems

What is the present period for comparison?

- 1960-1990

The greenhouse signal is rather weak

Relevant European programs

- STARDEX (Statistical and Regional Dynamical Downscaling of Extremes for European Regions): to evaluate statistical and dynamical downscaling methods to produce future scenarios for extreme events
- MICE (Modelling the Impacts of Climate Extremes): to estimate future impacts of extreme event change on human activities
- PRUDENCE (Prediction of Regional Scenarios and Uncertainties for Defining European Climate Change Risks and Effects): to evaluate the deficiencies in future projections

Current Relevant European programs

ENSEMBLES (Ensembles based predictions on climate changes and their impacts)

- To develop an ensemble prediction system for climate change based on global and regional models developed in Europe,
- to produce for the first time, an objective probabilistic estimate of uncertainty in future climate
- To quantify and reduce the uncertainty in the representation of physical, chemical, biological and human-related feedbacks in the Earth System
- To maximise the exploitation of the results by linking the outputs to a range of applications, including agriculture, health, food security, energy, water resources, insurance and weather risk management

77 participants Running period: 2004-2009

http://www.ensembles-eu.org/

Current Relevant European programs

- CECILIA (Central and Eastern Europe Climate Change Impact and VulnerabiLIty Assessment): 2006-2009
- CLAVIER (Climate Change and Variability in Central and Eastern Europe): 2006-2009
- CIRCE (Climate Change and Impact research: the Mediterranean Environment):2007-2010

What governments are doing?

Intergovernmental Panel for Climate Change (IPCC) (1988)

to bring together scientists from all around the world to assess existing research about climatic changes and effects and to report on it

UN Famework Convention on Climate Change (1992)

- To stabilize the greenhouse gas concentrations
- To monitor and report the greenhouse gases produced and develop strategies

189 countries agreed

What governments are doing?

Kyoto protocol (in legal force since February 2005)

- Each industrialised country has to reduce the greenhouse gas emissions and reach certain emission target by 2012
- 150 countries adopted it (including 25 EU countries)
- US and Australia did not participate
- 36 countries have target to reduce emissions by 5-8% from 1990 levels

What EU is doing?

EU produces 11 tonnes per citizen every year

Under Kyoto protocol

- 15 members to reduce their collective emissions by 8% (separate target for each country: e.g. -21% by Denmark and Germany, -12.5% by UK, +25% by Greece, +15% by Spain, +27% by Portugal)
- 10 additional members (since 2004) have individual targets (ranging between 6-8%), except Cyprus and Malta that have no target

What EU is doing?

European Climate Change Programme (2000)

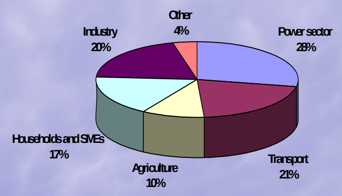
42 measures that help the members to reduce emissions in a cost-effective way

All measures have already become law or are in the process

- Cornerstone: EU emissions trading scheme
- Improvement of fuel efficiency of cars and energy efficiency of buildings
- Increase the use of renewable energy sources
- Controlling the fluorinated greenhouse gases used in air conditioning
- Use of climate friendly technologies (such as carbon capture and storage)

What EU is doing?

By 2002, the 15 former members had reduced emissions by 2.9% and the 25 members by 9% as compared to 1990 levels



Greenhouse gas emissions in the EU in 2001

What you can do?

- Recycling
- Save hot water
- Switch off lights when you do not need them
- Try energy-savings light bulbs
- Do not leave TV, stereo etc on standby
- Plant trees and flowers
- Do not leave the mobile phone charger plugged
- Buy graded "A" new electrical appliance
- Prefer eco-labeled goods
- Do not overheat your home
- Prefer public transport, cycling and walking

Changes in present climate

Objective: to present results from trends (tendencies) in the present temperature and precipitation regime over Greece

Data

- Daily data of maximum and minimum temperature:

20 Greek stations

- Daily data of precipitation:22 Greek stations

Period: 1958-2000

wet day:precipitation amount>1 mm

Trends of temperature

stations	a) Mean Tmax					b) Mean Tmin				
	DJF	MA	JJA	SON	AN	DJF	MAM	JJA	SON	ANN
Agrinio	-0.17	-0.01	0.02	-0.14	-0.08	-0.44	[illegible]	[illegible]	[illegible]	-0.20
Alexandroupoli	-0.13	[illegible]	[illegible]	[illegible]	-0.03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Athens	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Elliniko	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Herakleio	-0.28	[illegible]	[illegible]	[illegible]	-0.15	-0.02	[illegible]	[illegible]	[illegible]	0.10
Ierapetra	-0.34	-0.19	0.15	-0.12	-0.12	0.15	0.09	0.20	0.03	0.12
Ioannina	[illegible]	[illegible]	[illegible]	[illegible]	-0.08	-0.09	[illegible]	[illegible]	[illegible]	0.00
Kalamata	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.24
Kerkyra	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.10
Kozani	-0.01	[illegible]	[illegible]	-0.14	0.01	0.19	0.09	[illegible]	0.08	0.14
Kythira	-0.34	-0.18	0.11	-0.09	-0.13	0.07	0.05	[illegible]	[illegible]	0.15
Larissa	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Milos	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mytilini	[illegible]	[illegible]	[illegible]	[illegible]	0.00	-0.28	[illegible]	[illegible]	[illegible]	-0.10
Naxos	-0.15	0.06	0.29	0.15	0.09	0.13	0.13	0.31	0.30	0.21
Rodos	-0.26	-0.17	0.01	-0.28	-0.17	0.11	0.10	0.18	0.16	0.14
Samos	-0.07	0.08	0.18	-0.03	0.04	-0.66	-0.21	0.23	-0.55	-0.29
Skyros	-0.35	-0.07	0.14	-0.07	-0.09	-0.28	-0.18	0.07	-0.12	-0.13
Thessaloniki	0.07	0.05	0.27	-0.03	0.08	0.06	-0.09	0.04	-0.16	-0.03
Tripoli	-0.09	0.18	0.20	-0.36	-0.02	-0.38	-0.23	-0.17	-0.36	-0.30

Overall decreasing, except Athens

Overall increasing, but also negative trends

Decreasing in winter

Decreasing in winter

Increasing in summer

Increasing in summer

Source: Maheras et al. 2006

Trends of temperature percentiles

	a) Mean Tmax90p					b) Mean Tmin10p				
	DJF	MAM	JJA	SON	ANN	DJF	MAM	JJA	SON	ANN
Agrinio	-0.29	0.07	-0.03	-0.14	-0.06	-0.44	-0.69	0.26	-0.57	-0.65
Alexandroupoli	-0.24	[illegible]	[illegible]	[illegible]	0.11	[illegible]	[illegible]	[illegible]	[illegible]	-0.18
Athens	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Elliniko	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.20
Herakleio	-0.36	-0.11	[illegible]	-0.04	-0.08	0.10	-0.20	[illegible]	-0.06	-0.02
Ierapetra	-0.50	0.14	0.28	0.05	0.16	0.34	-0.05	0.37	-0.01	0.15
Ioannina	-0.38	[illegible]	[illegible]	[illegible]	0.09	0.05	[illegible]	[illegible]	[illegible]	-0.18
Kalamata	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Kerkyra	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.38	[illegible]	[illegible]	[illegible]	[illegible]
Kozani	0.09	-0.08	[illegible]	0.14	0.19	0.43	-0.21	[illegible]	-0.36	0.06
Kythira	-0.43	-0.07	0.14	0.02	0.04	0.11	-0.01	0.32	-0.13	0.02
Larissa	-0.28	[illegible]	[illegible]	[illegible]	0.03	-0.01	[illegible]	[illegible]	[illegible]	-0.13
Milos	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mytilini	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Naxos	-0.18	0.22	[illegible]	0.60	0.35	0.40	0.02	[illegible]	0.10	0.11
Rodos	-0.42	-0.18	-0.14	-0.17	-0.11	0.56	0.17	0.25	0.14	0.22
Samos	-0.16	0.37	0.41	0.16	0.26	-0.60	-0.61	-0.11	-1.09	-0.71
Skyros	-0.38	-0.09	0.21	0.35	0.13	-0.17	-0.48	0.23	-0.44	-0.35
Thessaloniki	-0.08	0.08	0.20	0.27	0.21	0.13	-0.21	0.14	-0.61	0.06
Tripoli	0.02	0.27	0.44	-0.33	0.21	-0.54	-0.57	0.00	-0.64	-0.60

Overall increasing

Overall decreasing

Increasing in summer

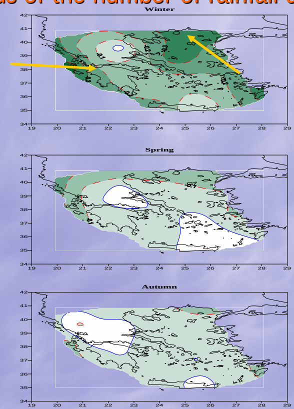
Increasing in summer

decreasing in winter

decreasing in winter

Source: Maheras et al. 2006

Trends of the number of rainfall days



winter

Decreasing trend

Statistically insignificant trends

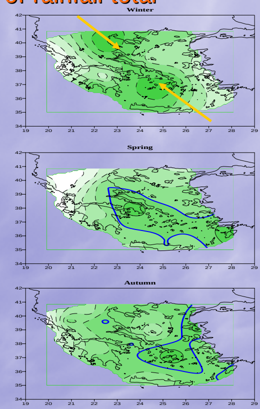
spring

Decreasing trend statistically insignificant

autumn

Source: Maheras et al. 2004

Trends of rainfall total



Decreasing trend

winter

Decreasing trend

spring

Decreasing trend

autumn

Source: Maheras et al. 2004

Changes in future climate

Objectives:

To estimate future potential changes concerning:

- the regime of mean temperature and precipitation
- The occurrence of extreme climatic events, such as frost, heat waves, dry spells, intense rainfall

over Eastern Mediterranean in the end of 21th century

Based on the results of a regional climatic model for two different scenarios of evolvement of the future atmospheric concentrations of greenhouse gases

Data

Results of the climatic model HADRM3P (Hadley Centre, UK)

Boundary conditions by the Global Model HadAM3P

Spatial resolution: 0,44˚x 0,44˚ (50Km x 50Km over Europe)

Parameters: Maximum and minimum temperature, precipitation (daily values)

Present: 1960-1990 *Future: 2070-2100*

Available through MICE and ENSEMBLES

Methodology

Estimate and plot the differences (changes) for every parameter:

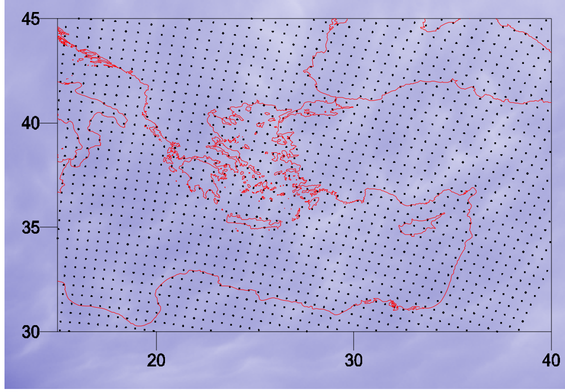
future (2070-2100)-present (1960-1990) values

On annual and seasonal basis

For two IPCC scenarios: A2 and B2

Check for statistical significance of the differences at 0.05 level

Eastern Mediterranean grids used by the model



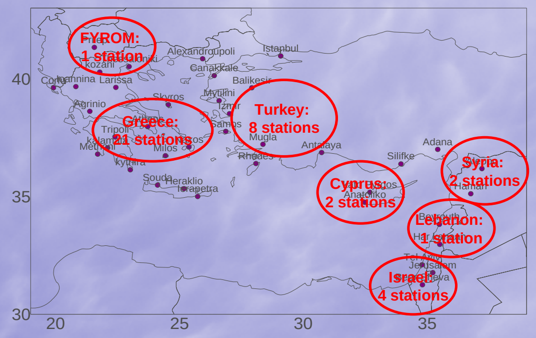
Model Validation

Period: 1960-1990

Comparison between model and station data on a seasonal and annual basis

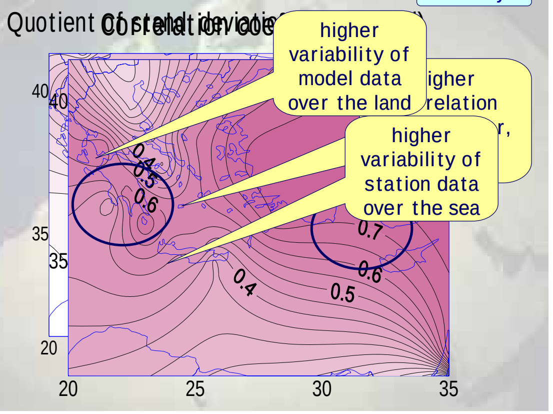
- Linear Correlation Analysis
- Quotient of the standard deviation (station/model)
- Comparison of spatial distributions

Eastern Mediterranean Stations:39



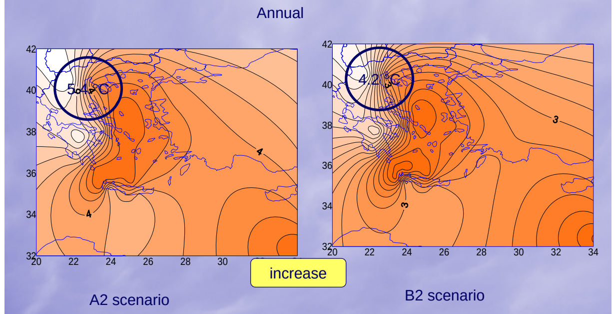
Model Validation

annually



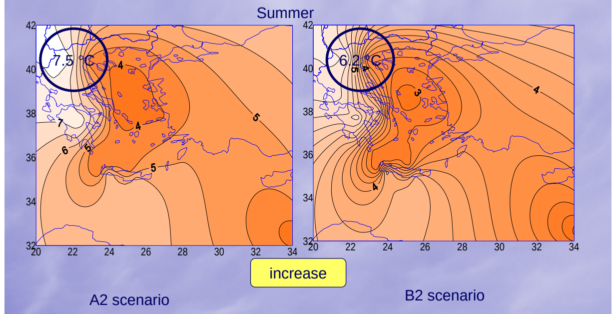
Changes in mean maximum temperature

Annual



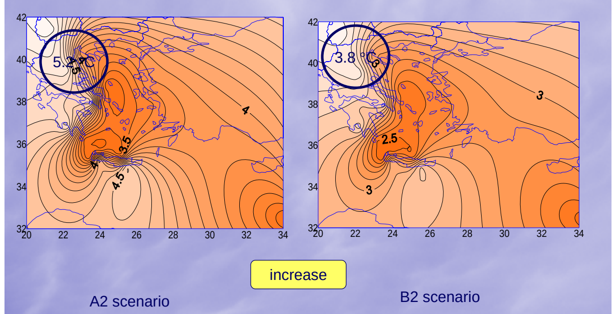
Changes in mean maximum temperature

Summer



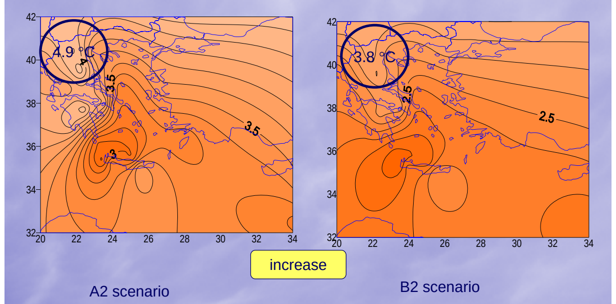
Changes in mean minimum temperature

Annual



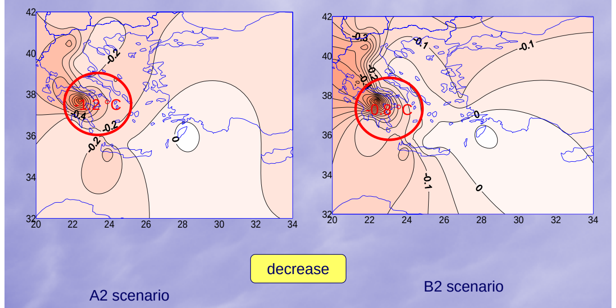
Changes in mean minimum temperature

Winter

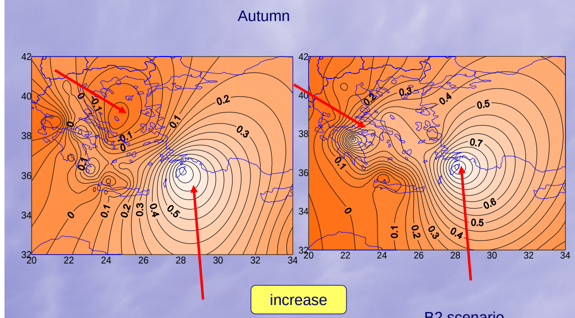


Changes in mean precipitation (mm/day)

Annual



Changes in mean precipitation (mm/day)



A2 scenario

B2 scenario

Identification of extremes

Employment of Climatic Indices

Annual and seasonal basis

Why to employ indices?

- useful and consistent approach, without using different threshold values for each station
- relevant in terms of impacts
- transferable across a range of different climatic regimes and makes the results in Eastern Mediterranean comparable with those in other European regions
- Recommended by European project STARDEX and WMO

EXTREME PRECIPITATION EVENTS: definition

- Extremely long dry spells:

Maximum number of consecutive dry days (CDD)

- Intense rainfall:

Number of days with rainfall amount greater than the 90% of the rainfall distribution during wet days (Pnl90)

WET DAY: precipitation amount ≥ **1mm**

EXTREME TEMPERATURE EVENTS:definition

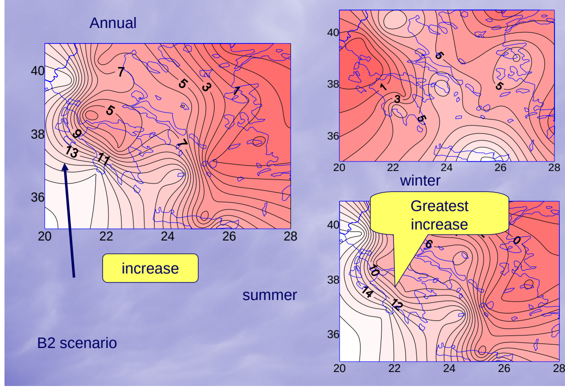
- Frost :

Number of days with minimum temperature less than 0°C (Tnfd)

- Heat wave duration:

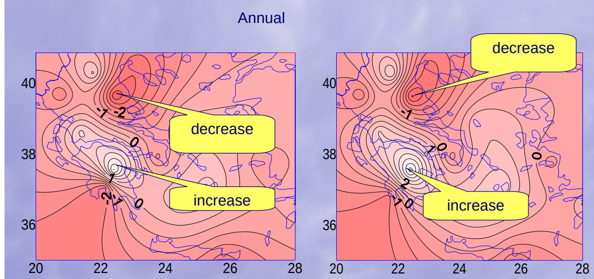
Maximum number of consecutive days with maximum temperature greater than the 90% of the maximum temperature distribution for every day (using five days window) (Txhw90)

Changes in the duration of extreme dry spells



B2 scenario

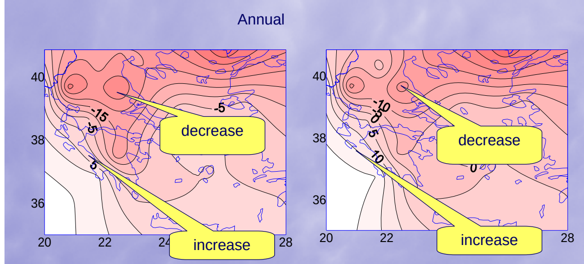
Changes in the number of intense rainfall days



A2 scenario

B2 scenario

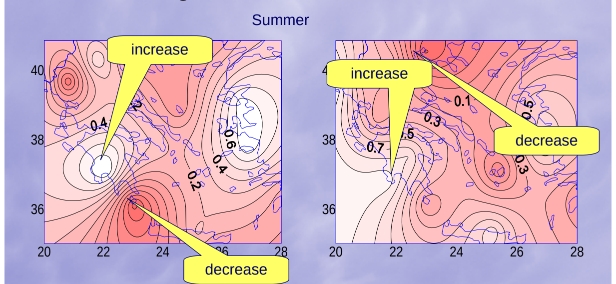
Changes in the number of frost days



A2 scenario

B2 scenario

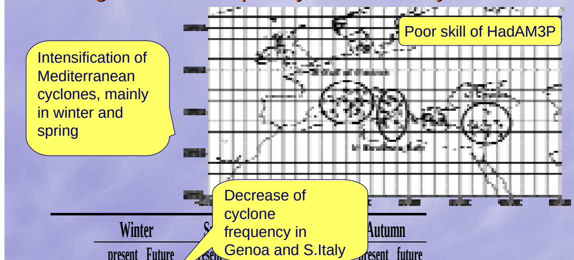
Changes in heat wave duration



A2 scenario

B2 scenario

Changes in the frequency of intense cyclones



	Winter		S				Autumn	
	present	Future	present				present	future
Genoa	20	12	38	23	1	4	15	10
Italy	21	12	40	40	0	3	7	5
Cyprus	4	4	3	12	23	85	2	4

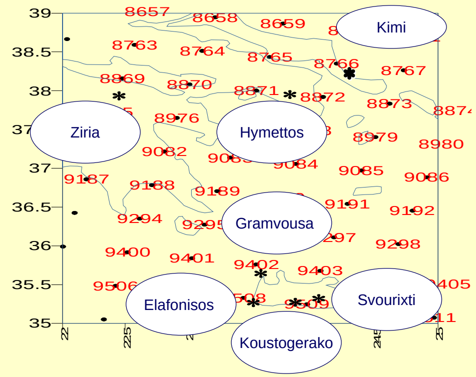
Source: Anagnostopoulou et al., 2006

Input for SEMCLIMED experiments

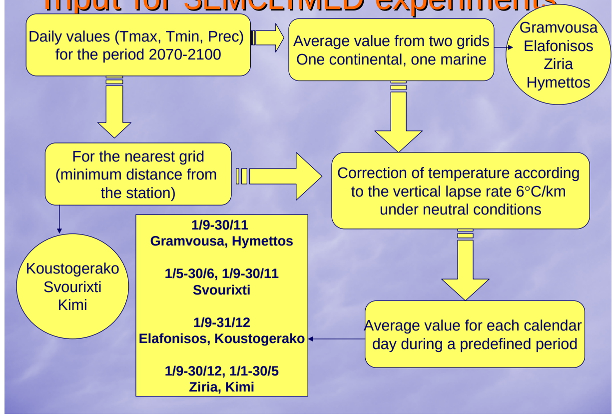
Objective:

- to assess the impact of future climatic changes on the seed germination behaviour of a number of selected, Mediterranean plant species
- to assess their future geographic occurrence and *in situ* conservation status.

Input for SEMCLIMED experiments



Input for SEMCLIMED experiments



Input for SEMCLIMED experiments

Gramvousa

date	control run (present)				future					
	prec	temp	tmax	tmin	prec A2a	prec B2a	tmax A2a	tmax B2a	tmin A2a	tmin B2a
1/9	0,25	24,98	25,59	24,42	[illegible]	0,66	29,96	28,69	[illegible]	27,62
2/9	0,26	24,89	25,47	24,38	[illegible]	[illegible]	29,91	28,67	[illegible]	[illegible]
3/9	0,30	24,74	25,29	24,25	[illegible]	[illegible]	29,68	28,61	[illegible]	[illegible]
4/9	0,32	24,62	25,13	24,16	[illegible]	[illegible]	29,59	28,57	[illegible]	[illegible]
5/9	0,42	24,69	25,18	24,27	[illegible]	[illegible]	29,65	28,39	[illegible]	[illegible]
6/9	0,61	[illegible]	[illegible]	24,38	[illegible]	[illegible]	29,53	28,30	[illegible]	[illegible]
7/9	0,44	[illegible]	[illegible]	24,23	0,42	0,47	29,25	[illegible]	28,14	27,35
8/9	[illegible]	[illegible]	[illegible]	24,08	1,36	0,10	[illegible]	[illegible]	[illegible]	27,48
9/9	[illegible]	[illegible]	[illegible]	[illegible]	0,53	0,09	[illegible]	[illegible]	[illegible]	27,37
10/9	[illegible]	[illegible]	[illegible]	[illegible]	0,66	0,13	[illegible]	[illegible]	[illegible]	27,22
11/9	[illegible]	[illegible]	[illegible]	[illegible]	0,09	0,18	[illegible]	[illegible]	[illegible]	27,31
12/9	[illegible]	[illegible]	[illegible]	[illegible]	0,53	0,28	[illegible]	[illegible]	[illegible]	27,20
13/9	[illegible]	[illegible]	[illegible]	23,63	0,39	0,26	[illegible]	[illegible]	[illegible]	26,95
14/9	0,98	[illegible]	[illegible]	23,71	0,12	0,12	[illegible]	[illegible]	[illegible]	26,74
15/9	0,87	[illegible]	[illegible]	23,88	0,34	0,31	28,85	27,79	27,80	26,61
16/9	1,01	24,15	24,67	23,69	1,22	0,40	28,88	27,62	27,67	26,54
17/9	0,20	23,95	24,45	23,48	0,56	0,60	28,65	27,34	27,64	26,36
18/9	1,11	23,59	24,17	23,09	0,64	0,85	28,44	27,44	27,41	26,37
19/9	2,18	23,54	24,03	23,05	0,34	0,96	28,31	27,39	27,38	26,32
20/9	1,37	23,62	24,09	23,06	0,50	1,09	28,15	27,00	27,16	26,02
21/9	0,73	23,52	24,03	23,09	0,60	2,63	27,89	26,89	26,95	26,12
22/9	0,75	23,53	24,06	23,04	1,17	2,34	27,75	26,89	26,74	25,89
23/9	1,01	23,49	23,97	23,05	1,72	0,30	27,57	26,74	26,53	25,88
24/9	0,87	23,37	23,82	22,93	3,41	0,19	27,61	26,75	26,48	25,79
25/9	1,46	23,23	23,76	22,71	1,40	0,64	27,66	26,63	26,76	25,69
26/9	0,66	23,16	23,62	22,72	0,95	0,75	27,59	26,56	26,61	25,63
27/9	0,83	23,27	23,70	22,86	0,32	1,63	27,35	26,51	26,45	25,54
28/9	1,24	23,19	23,66	22,73	0,34	2,34	27,18	26,45	26,31	25,48
29/9	1,55	22,89	23,44	22,42	0,61	2,40	27,24	26,38	26,31	25,23
30/9	1,23	22,73	23,26	22,28	0,55	1,00	27,25	26,12	26,45	25,18

A2 scenario

B2 scenario

Average based on 1960-1990 period

Average based on 2070-2100 period

Uncertainties in future predictions

- Uncertainty regarding the population evolution, the socio-economic development and technology
- ... of the re... ected warming ... ls
- Not complete or not correct representation of important physical and chemical processes in the climatic models, such as ocean-atmosphere interaction, carbon cycle, aerosol chemistry

Uncertainty in the temperature prediction up to **4 °C (!!)** depending on the scenario

Uncertainty in the prediction of CO_2 concentration 10-30%

Uncertainties in future predictions

Project ENSEMBLES:

estimate the uncertainties of future climatic predictions

- The natural variab... predicted
- Inability of the models to include very detailed topography and its influence in the regional climate

the uncertainty of the future predictions depend on:

- **Calculation inabilities/limitations**
- **resolution and efficiency**

of each climatic model used

Why to perform climatic predictions?

- estimate the impacts
- stimulate implementation of measures
- climate models are the best available tool at this moment for long range predictions
- continuing research to improve the climatic predictions

Conclusions

Drier and hotter Eastern Mediterranean with reduced rainfall intensity

- Increase of maximum temperature ranging between 3 °- 5.4°C (2.3-4.2°) for A2 (B2) scenario. Maximum increase in summer
- Increase of minimum temperature ranging between 3 °- 5.2°C (2.3-3.8°) for A2 (B2) scenario. Maximum increase in winter

Conclusions

- Overall reduction of precipitation, up to 1.2 mm/day (0.8) for A2 (B2) scenario. Substantial seasonal and spatial differences. In autumn, there is an increase in Eastern Aegean and Cyprus.
- Longer dry spells for all seasons, except autumn.
- Reduction of the number of frost days, mainly in winter

Conclusions

- Decrease of rainfall intensity. Increase in autumn, mainly in Cyprus
- Reduction of the number of days with intense precipitation, except in Western Greece (there is an increase)
- Overall increase of heat wave duration. Substantial spatial differences
- Substantial differences between the two scenarios: the large increase of global warming, the more drastic changes are expected in mean and extreme climate

Conclusions

- Serious impact on various sectors in Mediterranean (MICE report, 2006):

✓ Substantial water deficit

✓ Reduction in yields, especially in Mediterranean due to:
  - shorter growing season
  - extreme events during development stages (higher risk of heat stress during flowering period, higher risk of rainy days during sowing dates
  - higher rainfall intensity
  - longer dry spells

Conclusions

- Serious impact on various sectors in Mediterranean (MICE report, 2006):

✓ Increased risk of forest fires due to higher number of dry/hot days, longer dry and hot spells, longer season with meteorological fire risk

✓ Increasing trend in energy demand (peak in December and July)

✓ Discourage of Mediterranean summer holidays due to drought and heat waves

✓ There is likely to be a shift in the Mediterranean holiday season to spring and autumn

✓ Subsequent economic implications

Research is continuing……….

Hope that these pessimistic predictions will not get true !!!!!!!

Thank you..

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