CLIMATE CHANGES IN EASTERN MEDITERRANEAN

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Contents

- Trends in present climate of Greece
- Climatic models-Future Scenarios
- Future climatic changes in Eastern Mediterranean
- Input for SEMCLIMED experiments

Sulphate and aerosol emission... cooling 0.5...

deforestation, urbanization: urban heat island

Enhanced greenhouse effect, ozone hole

Yet unclear contri...n to the greenhouse eff... enhancement

Na...

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

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

Climate 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

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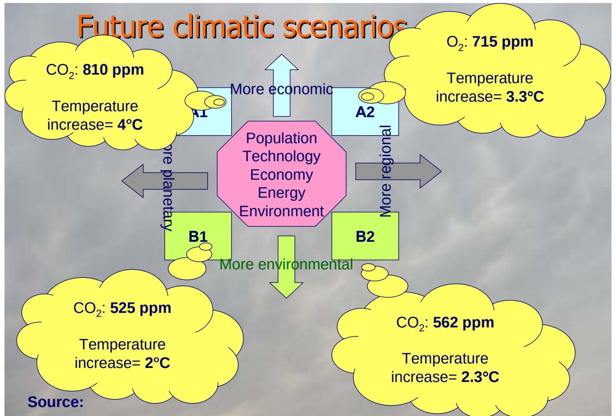
Future climatic scenarios



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

Changes in present climate

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	-0.28	[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]	[illegible]	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

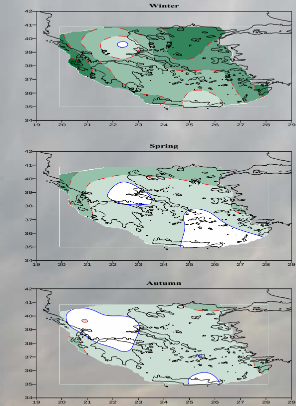
Decreasing in winter

Increasing in summer

Increasing in summer

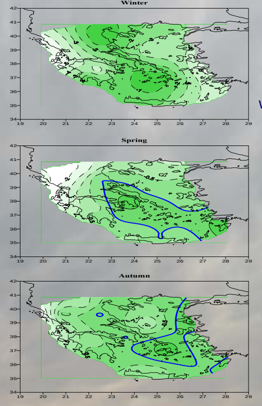
Source: Maheras et al. 2006

Trends of the number of rainfall days



Source: Maheras et al. 2004

Trends of rainfall total



Source: Maheras et al. 2004

Changes in future climate

Data

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

Boundary conditions by the Global Model HadAM3P

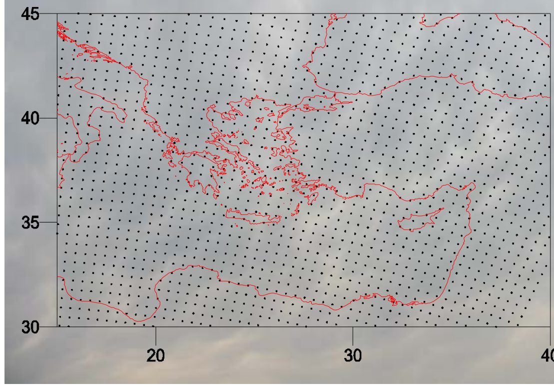
Spatial resolution: 0,44 x 0,44 (50Km x 50Km over Europe)

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

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

Available through MICE and ENSEMBLES

Eastern Mediterranean grids used by the model



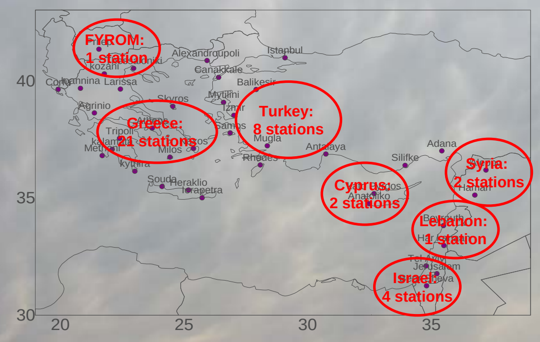
Model Validation

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
- Comparison of inter-annual variations

Eastern Mediterranean Stations:39

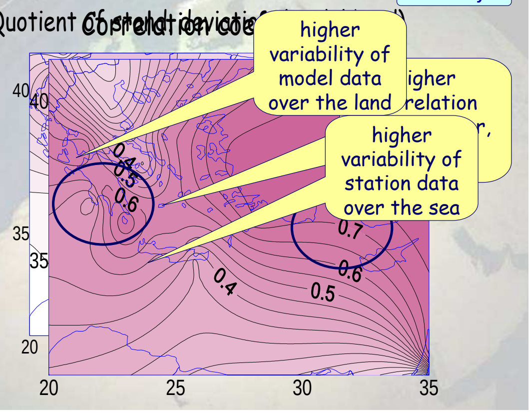


Model Validation

annually

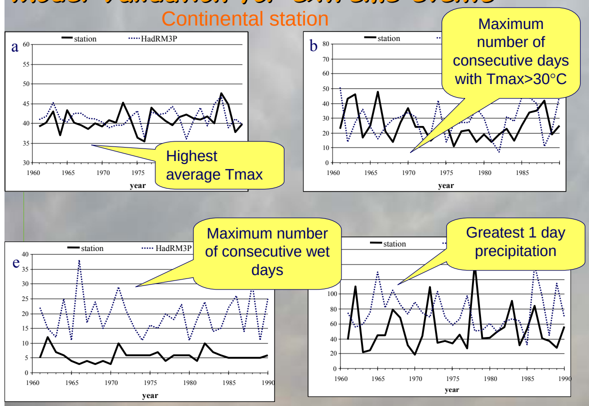
Quotient of standard deviation

Correlation coefficient



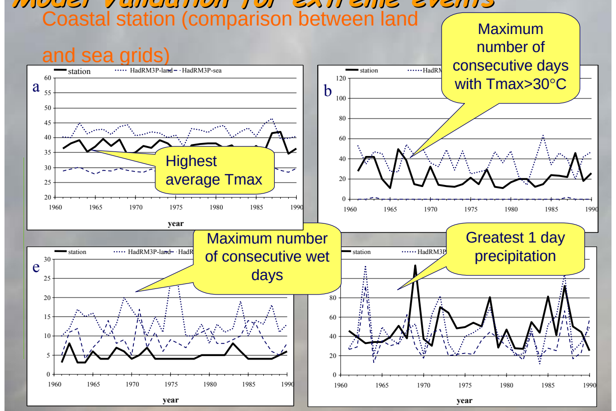
Model Validation for extreme events

Continental station



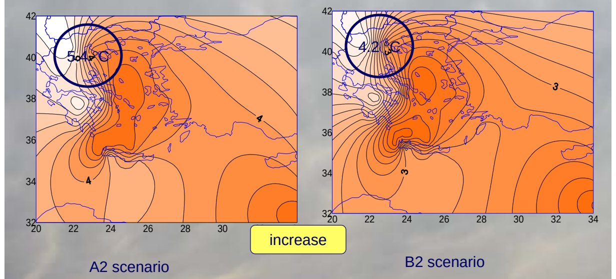
Model Validation for extreme events

Coastal station (comparison between land and sea grids)

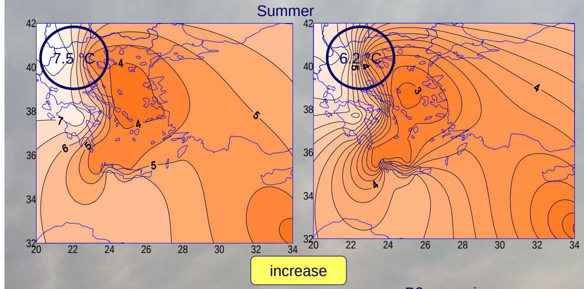


Changes in mean maximum temperature

Annual



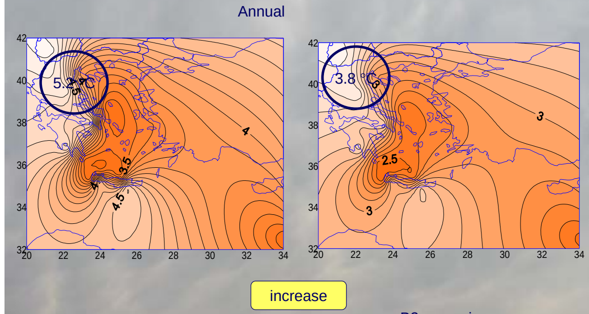
Changes in mean maximum temperature



A2 scenario

B2 scenario

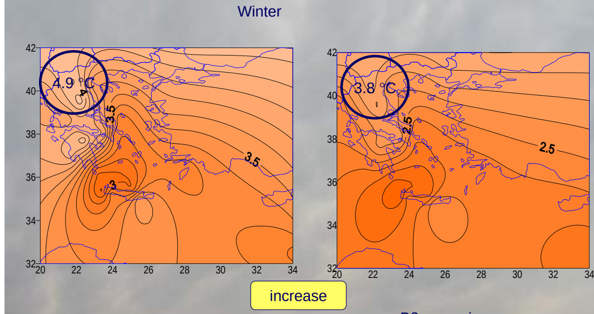
Changes in mean minimum temperature



A2 scenario

B2 scenario

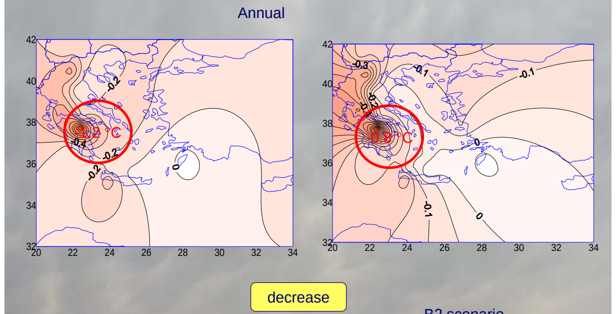
Changes in mean minimum temperature



A2 scenario

B2 scenario

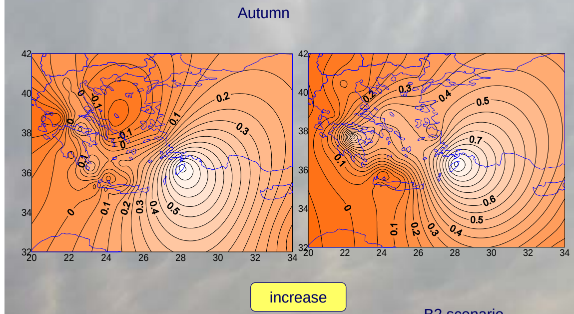
Changes in mean precipitation (mm/day)



A2 scenario

B2 scenario

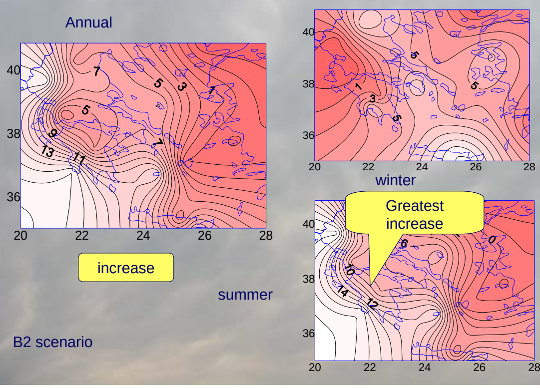
Changes in mean precipitation (mm/day)



A2 scenario

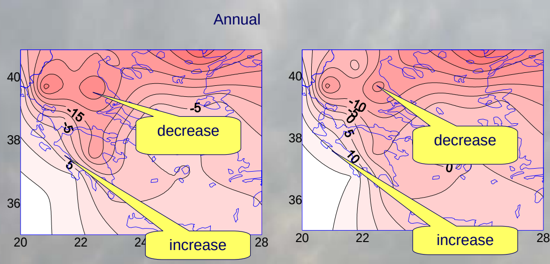
B2 scenario

Changes in the duration of extreme dry spells



B2 scenario

Changes in the number of frost days



A2 scenario

B2 scenario

What is expected for the future?

Drier and hotter Eastern Mediterranean with reduced rainfall intensity

- Increase of maximum temperature Maximum increase in summer
- Increase of minimum temperature ranging. Maximum increase in winter
- Overall reduction of precipitation. Substantial seasonal and spatial differences. In autumn, there is an increase in Eastern Aegean and Cyprus.

What is expected for the future?

- Longer dry spells for all seasons, except autumn.
- Reduction of the number of frost days, mainly in winter
- Substantial differences between the two scenarios: the large increase of global warming, the more drastic changes are expected in mean and extreme climate

What is expected for the future?

- 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

What is expected for the future?

- 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

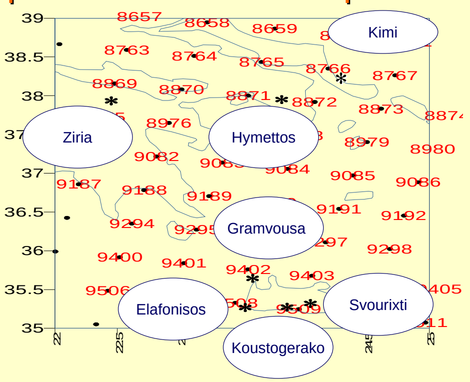
✓Subsequent economic implications

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

Daily values (Tmax, Tmin, Prec) for the period 2070-2100

Average value from two grids One continental, one marine

Gramvousa Elafonisos Ziria Hymettos

For the nearest grid (minimum distance from the station)

Koustogerako Svourixti Kimi

Correction of temperature according to the vertical lapse rate 6°C/km under neutral conditions

1/9-30/11 Gramvousa, Hymettos

1/5-30/6, 1/9-30/11 Svourixti

1/9-31/12 Elafonisos, Koustogerako

1/9-30/12, 1/1-30/5 Ziria, Kimi

Average value for each calendar day during a predefined period

Input for Greece

Gramvousa

	control run (present)				future					
date	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]	[illegible]	29,96	28,69	[illegible]	27,62
2/9	0,26	[illegible]	25,47	24,38	[illegible]	[illegible]	29,91	28,67	[illegible]	[illegible]
3/9	[illegible]	[illegible]	25,29	24,25	[illegible]	[illegible]	29,68	28,61	[illegible]	[illegible]
4/9	[illegible]	[illegible]	[illegible]	24,16	[illegible]	[illegible]	29,59	28,57	[illegible]	[illegible]
5/9	[illegible]	[illegible]	[illegible]	24,27	[illegible]	[illegible]	29,65	28,39	[illegible]	[illegible]
6/9	[illegible]	[illegible]	[illegible]	24,38	[illegible]	[illegible]	29,53	28,30	[illegible]	[illegible]
7/9	[illegible]	[illegible]	25,30	24,23	0,42	0,47	29,25	28,41	28,14	27,35
8/9	0,22	[illegible]	25,30	24,08	1,36	0,10	29,24	28,54	28,08	27,48
9/9	0,61	24,63	25,26	23,99	0,53	0,09	29,28	28,47	28,20	27,37
10/9	0,14	24,33	24,95	23,80	0,66	0,13	29,24	28,15	27,99	27,22
11/9	0,52	24,19	24,79	23,69	0,09	0,18	28,97	28,18	27,83	27,31
12/9	0,30	24,13	24,67	23,70	0,53	0,28	28,76	28,15	27,62	27,20
13/9	1,07	24,08	24,57	23,63	0,39	0,26	28,71	28,02	27,71	26,95
14/9	0,98	24,15	24,62	23,71	0,12	0,12	28,83	27,87	27,72	26,74
15/9	0,87	24,24	24,69	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	[illegible]	[illegible]	23,48	0,56	0,60	28,65	27,34	27,64	26,36
18/9	[illegible]	[illegible]	[illegible]	23,09	0,64	0,85	28,44	[illegible]	[illegible]	26,37
19/9	[illegible]	[illegible]	[illegible]	[illegible]	0,34	0,96	[illegible]	[illegible]	[illegible]	26,32
20/9	[illegible]	[illegible]	[illegible]	[illegible]	0,50	1,09	[illegible]	[illegible]	[illegible]	26,02
21/9	[illegible]	[illegible]	[illegible]	[illegible]	0,60	2,63	[illegible]	[illegible]	[illegible]	[illegible]
22/9	[illegible]	[illegible]	[illegible]	[illegible]	1,17	2,34	[illegible]	[illegible]	[illegible]	[illegible]
23/9	[illegible]	[illegible]	[illegible]	[illegible]	1,72	0,30	[illegible]	[illegible]	[illegible]	25,88
24/9	[illegible]	[illegible]	[illegible]	22,93	3,41	0,19	[illegible]	[illegible]	[illegible]	25,79
25/9	1,46	[illegible]	[illegible]	22,71	1,40	0,64	27,66	[illegible]	26,76	25,69
26/9	0,66	[illegible]	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

Control run

A2 scenario

B2 scenario

Average based on 1960-1990 period

Average based on 2070-2100 period

Input for Spain

Two locations: Sagunto (1-30/11), Ayora (20/10-30/11)

	prec_present	tmax_present	tmin_present	prec_A2a	prec_B2a	tmax_A2a	tmax_B2a	tmin_A2a	tmin_A2a
1	1,05	19,08	11,69	0,72	1,18	23,26	21,46	16,07	13,88
2	1,06	18,62	10,90	1,35	1,21	22,36	21,34	16,15	13,67
3	0,63	18,40	10,98	1,75	1,94	21,99	20,73	15,81	13,99
4	1,60	[illegible]	10,53	2,32	2,10	21,72	20,70	[illegible]	14,29
5	[illegible]	[illegible]	10,50	1,90	[illegible]	[illegible]	[illegible]	[illegible]	14,44
6	[illegible]	[illegible]	10,54	1,23	[illegible]	[illegible]	[illegible]	[illegible]	13,94
7	[illegible]	[illegible]	10,07	0,94	[illegible]	[illegible]	[illegible]	[illegible]	13,78
8	[illegible]	[illegible]	10,30	1,16	[illegible]	[illegible]	[illegible]	[illegible]	13,55
9	[illegible]	[illegible]	10,14	1,42	[illegible]	[illegible]	[illegible]	[illegible]	12,80
10	0,85	17,93	10,00	1,10	0,49	21,21	20,81	14,40	13,18
11	1,66	17,81	10,45	0,45	0,50	21,54	20,22	14,05	12,87
12	1,17	17,33	9,88	1,34	1,86	21,06	20,36	13,79	12,18
13	1,75	17,39	9,67	1,90	1,45	20,38	20,16	13,48	11,97
14	1,61	17,54	9,57	1,32	0,62	20,71	19,63	13,67	11,79
15	0,67	16,93	9,00	0,63	0,52	21,01	19,84	13,57	11,92
16	0,64	16,97	8,68	1,20	0,62	20,66	19,70	13,44	11,26
17	0,52	16,97	9,03	0,91	0,43	20,19	19,57	13,12	10,71
18	0,84	16,45	8,94	1,06	1,30	20,39	19,34	12,33	11,31
19	0,96	16,55	9,15	0,66	0,75	20,65	18,82	12,13	11,22
20	1,12	15,79	8,62	0,57	1,25	19,46	18,39	11,79	11,75
21	0,45	16,04	8,46	0,48	1,68	19,18	18,60	11,62	11,43
22	0,65	15,87	8,60	0,48	1,41	19,92	18,69	11,56	10,91
23	1,31	15,97	8,02	0,46	1,20	19,49	18,43	11,67	9,96
24	1,18	16,16	8,16	1,55	1,82	19,03	18,46	11,63	10,47
25	1,04	15,96	7,81	1,26	0,55	18,89	18,89	11,61	10,91
26	0,75	16,29	8,22	0,67	1,15	18,88	18,76	11,63	10,59
27	1,30	15,49	8,02	1,17	0,41	19,02	17,96	11,83	9,92
28	0,51	16,05	7,60	0,92	0,59	19,12	17,83	11,86	9,71
29	0,50	16,24	7,77	0,61	1,14	18,85	17,85	11,47	10,04
30	0,91	15,84	8,20	0,85	1,55	18,72	17,41	11,18	9,95

Control run

A2 scenario

B2 scenario

Uncertainties in future predictions

- Uncertainty regarding the population evolution, the socio-economic development and technology
- [illegible] of the re[illegible] [illegible]ected war[illegible] [illegible]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

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

Project ENSEMBLES:

estimate the uncertainties of future climatic predictions

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

Research is continuing……….

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

Thank you..

Related bibliography

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