THE POSSIBLE EFFECTS OF CLIMATE CHANGE ON HAZELNUT FARMING IN TURKEY

(Climate change impact assessment study)

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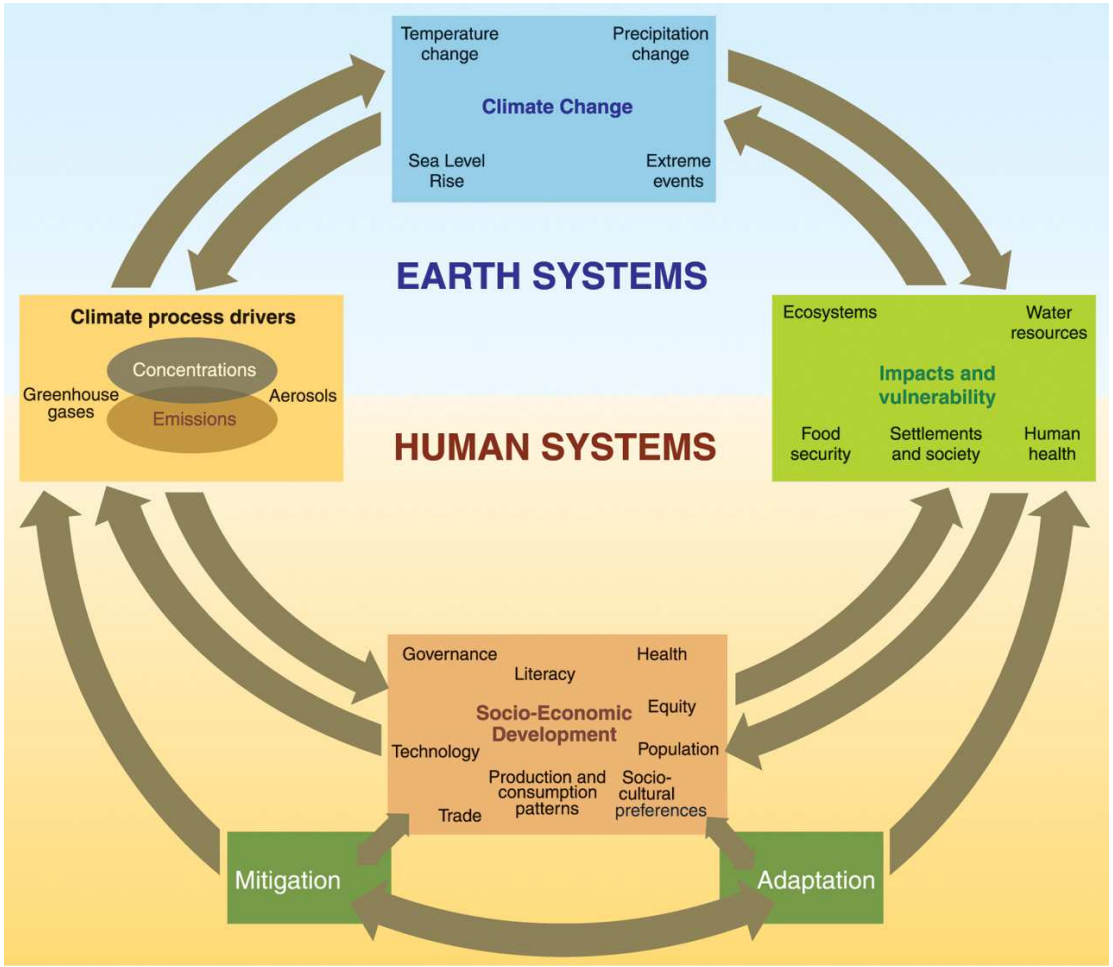
key questions

- ✓ which climatic factors are effective on hazelnut yield?
- ✓ according to the this / these factor(s), how can we determine spatiotemporal changes of hazelnut cultivated area in the future?

Idea and Concept:

Climate - agriculture relationship



literature

- In general, determining climate – yield relationship in present day condition, correlation coefficient and regression analysis were applied as method in the literatures (Kaufmann and Snell, 1997, Freckleton et al.,1999; Gadgil et al., 1999; Aleksandrov and Hoogenboom, 2000; 2001; Thompson, 1986; Stooksbury and Michaels, 1994; Perkey and Hayes, 2008).

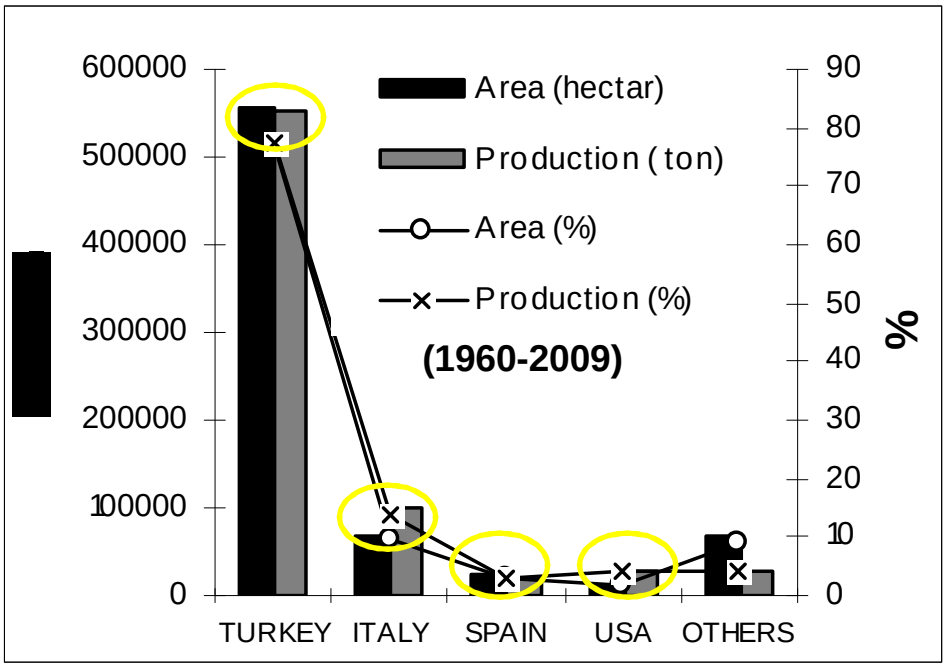
- For future analysis, particularly climate change scenarios data were used for temporal and spatial scale.

- In this study both present and future analysis have done using these statistical methods.

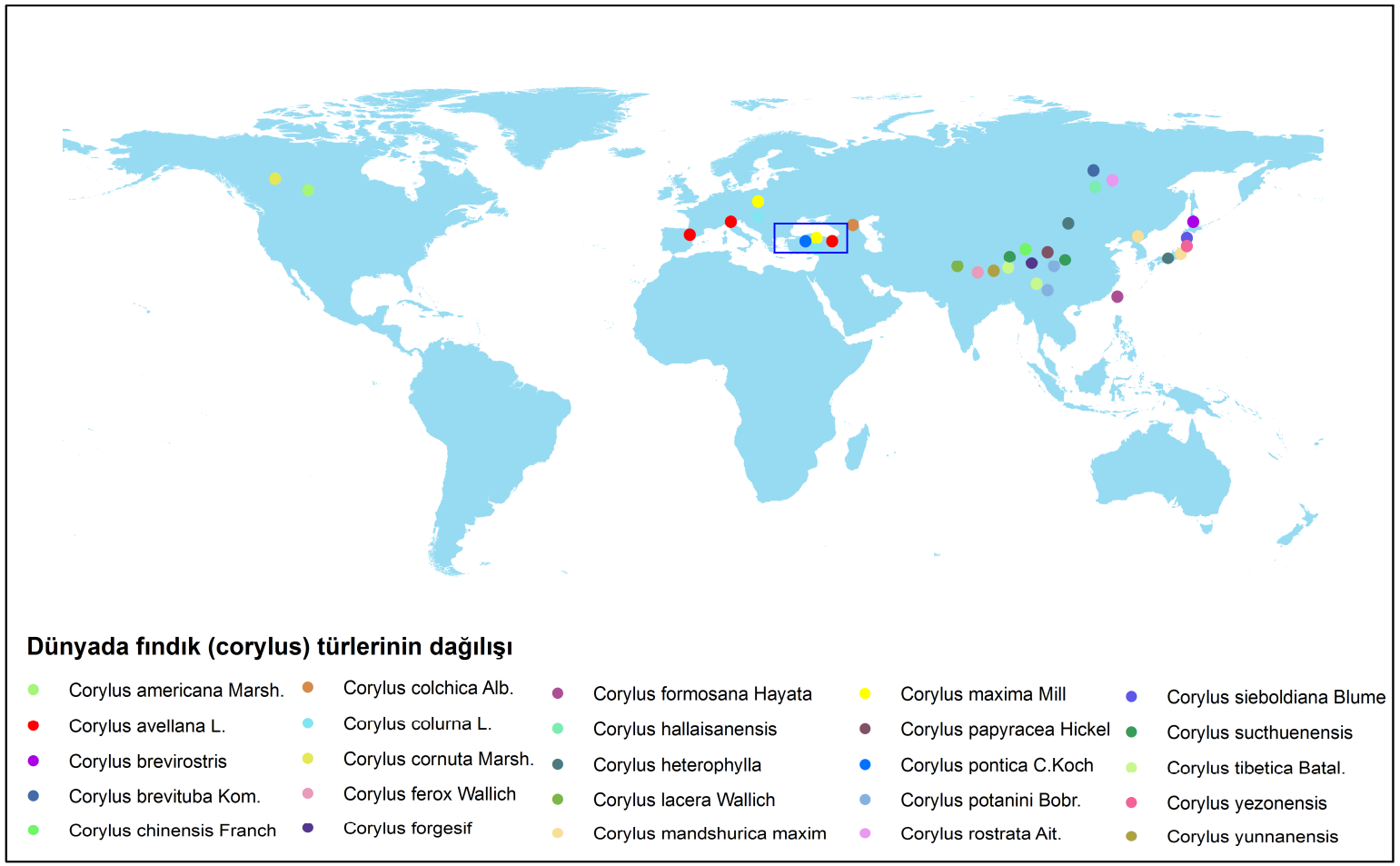
Idea and Concept:

Climate-agriculture relationship

Climate-hazelnut relationship

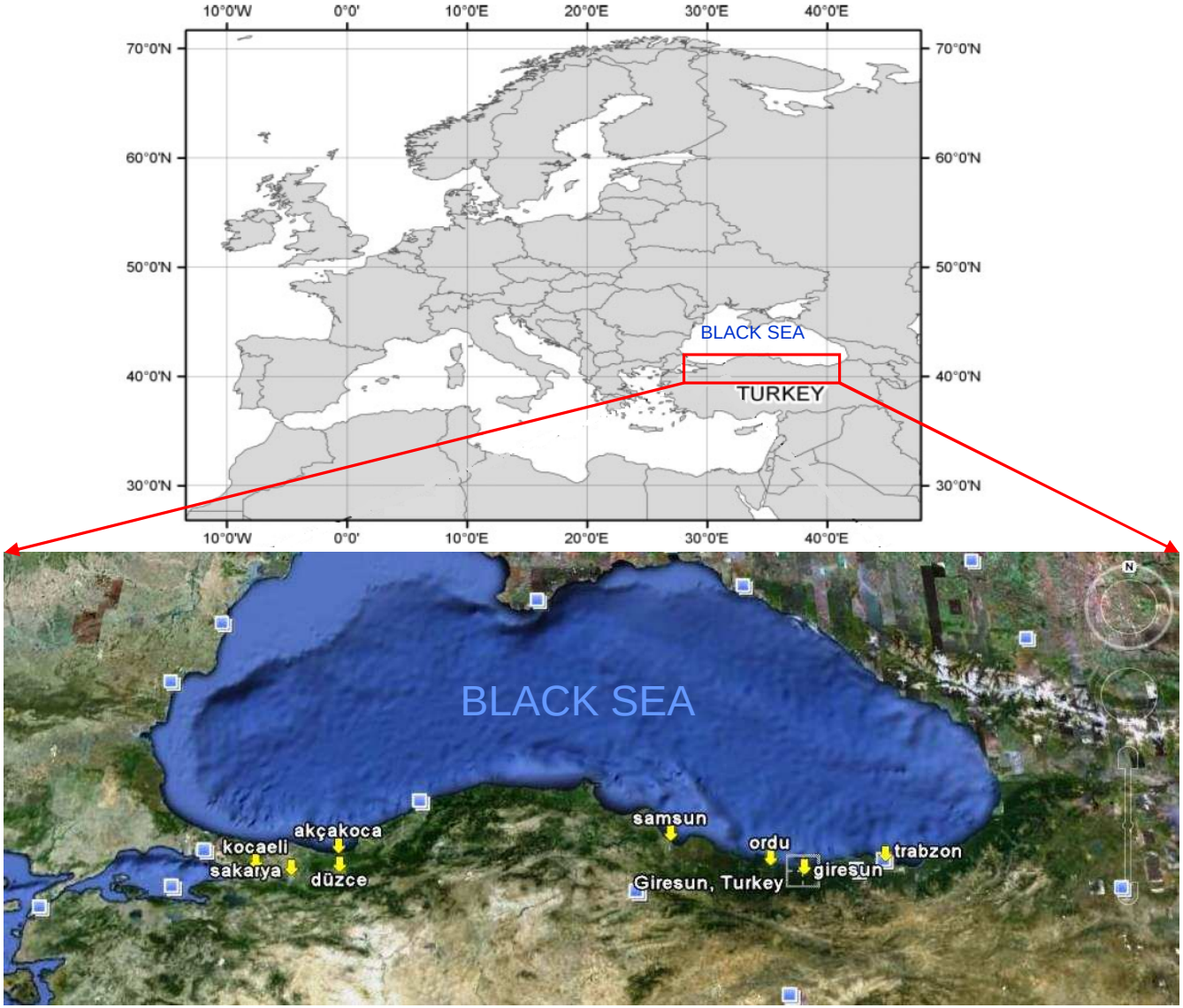


Distribution of corylus in the world



Resource: Koksal, 2002

Study area and its surrounding



Main Objectives

- determination of the most effective climatic condition on hazelnut yield in present day conditions using statistical methods
- examination the spatiotemporal variation of hazelnut cultivated area according to the most effective climatic parameter in the future analysing
- assessment of these changes and developing adaptation strategies.

If we understand today’s conditions, we will predict future more correctly

Data (past-present-future)

Past & Present
(1993 - 2009)

Hazelnut data:
Production (ton)
Cultivated area (kg/hec))
Yield (kg/hec))

Climate data:
Average temp (ºC)
Maximum temp(ºC)
Minimum temp(ºC)
Precipitation (mm)
Humudity (%)
Wind speed (m/sn)

Satellite data:
MODIS Terra (500 m.)

Future
(2011 - 2100)

Climate change scenario data:

Re-analysis data NCEP & NCAR (1961-1990)
A2 scenario data from ECHAM 5 RegCM3 (30 km res.)
Average ten years (2011-2020, 2021-2030…2090- 2100)
279 meteorological station data (1930-2009)

Altitude data:
GTOPO 30 digital elevation data (1 x 1 km)

MATLAB & ERDAS software

Methodology

- Special climate requirements analysis (defining climate thresolds of hazelnut)
- Phenological analysis (defining extreme meteorological events)
- Pearson correlation coefficient and simple linear regression analysis (relationship between climatic conditions and hazelnut yield)
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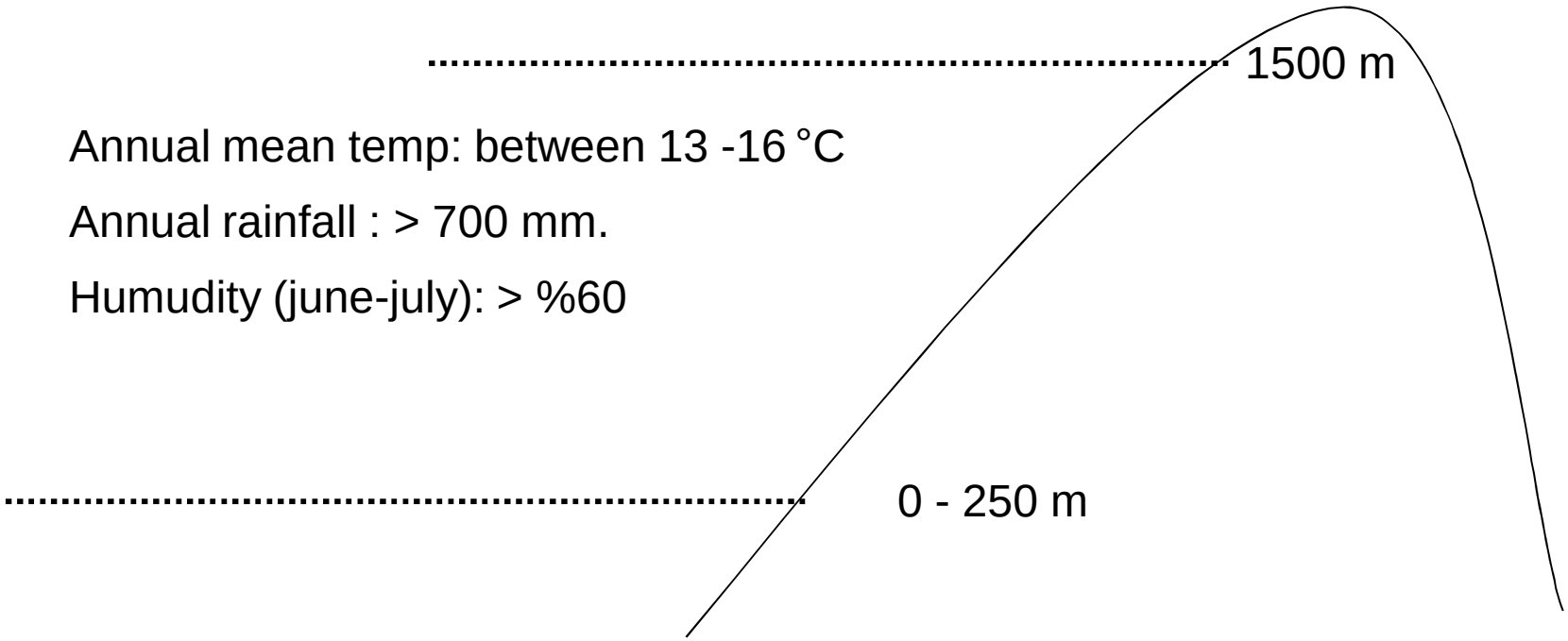
Special Climate Requirements of Hazelnut



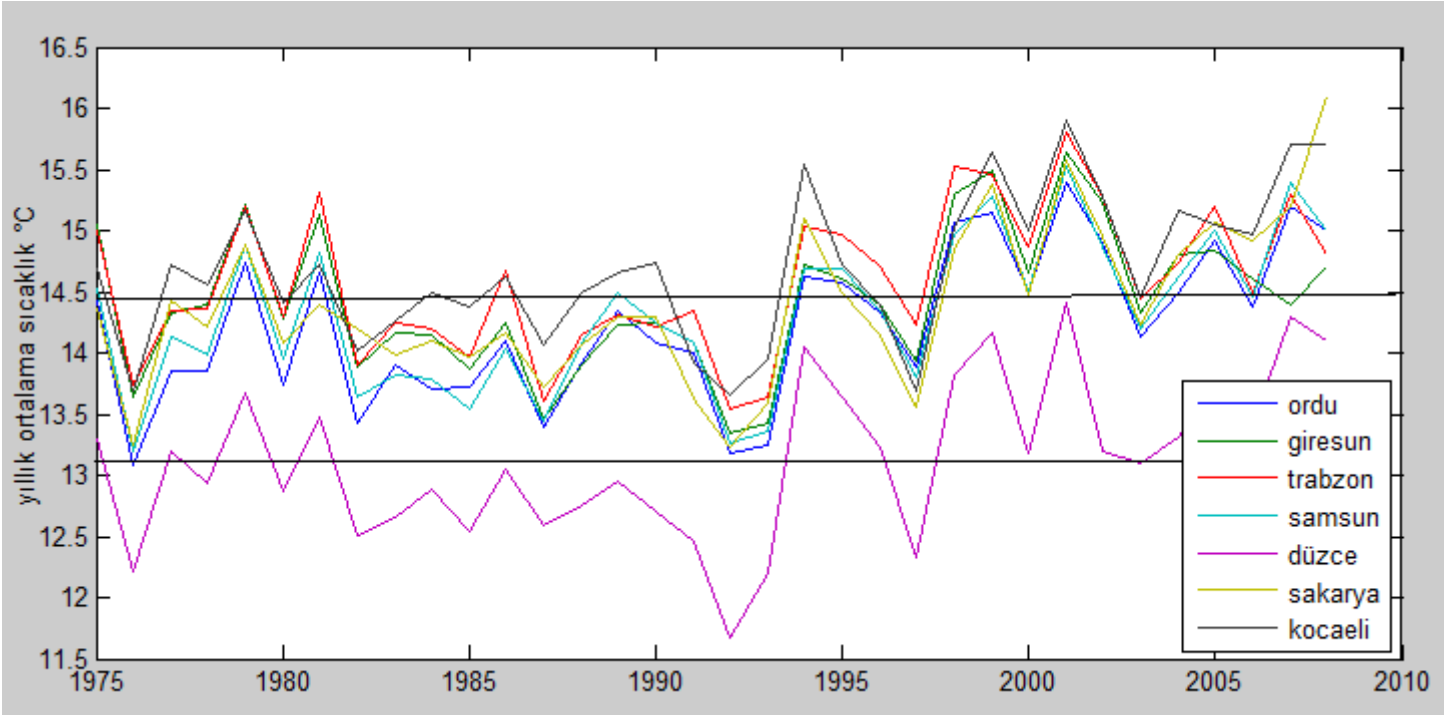
Annual mean temp: between 13 -16 °C

Annual rainfall : > 700 mm.

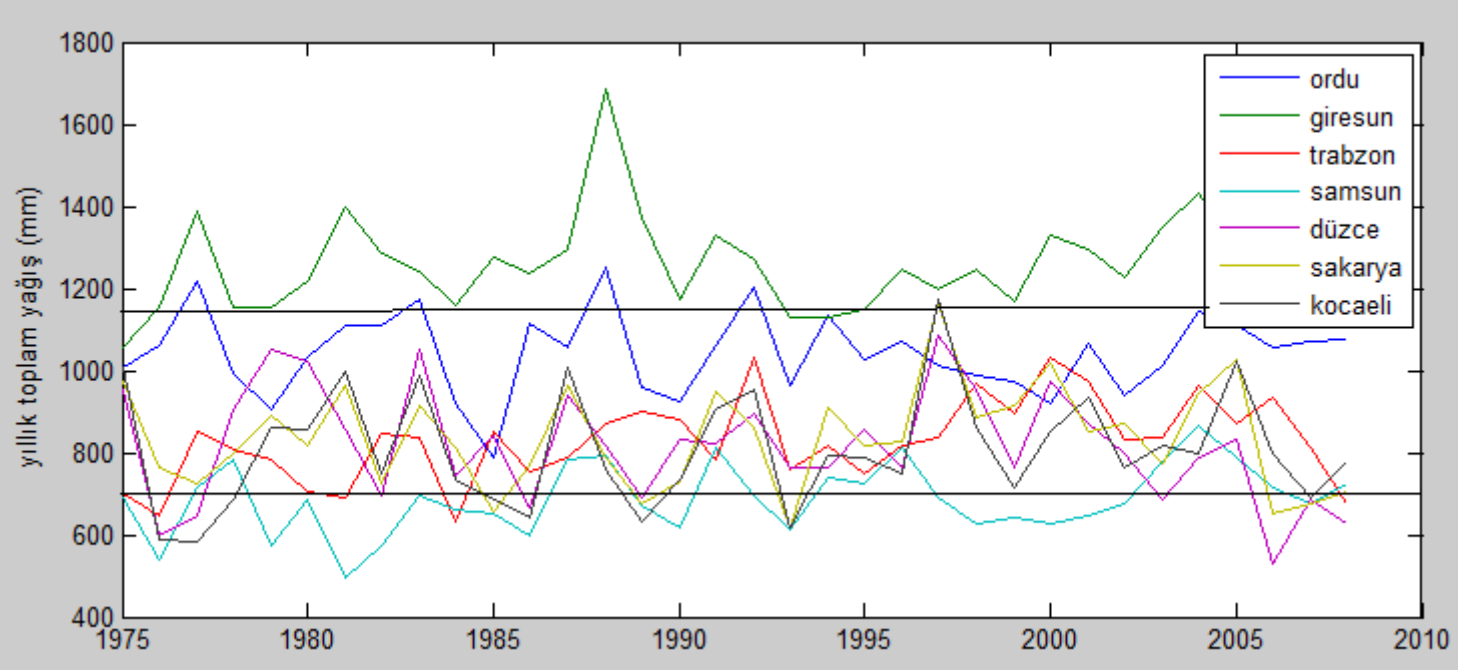
Humudity (june-july): > %60

Extreme meteorological events;
frost in flowering period and drought in fertilization and maturity period effective on yield

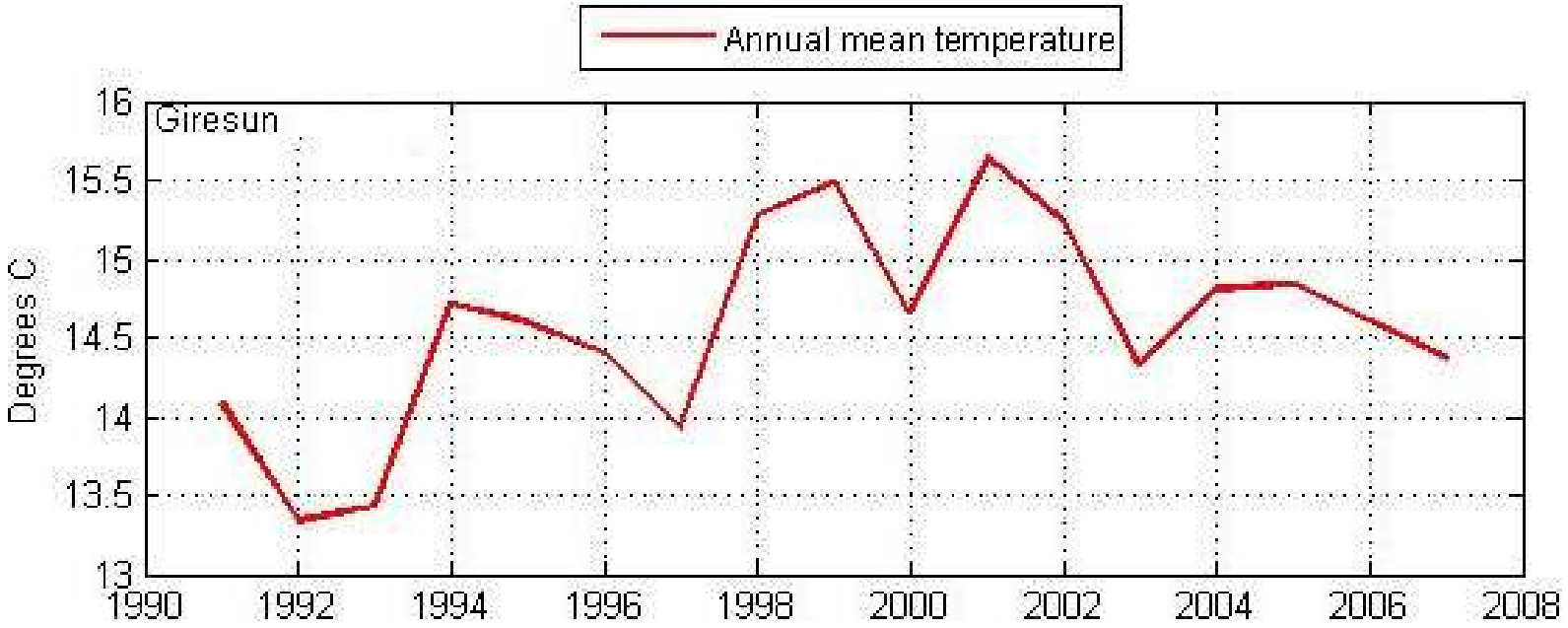
temperature (13 – 16 ℃)



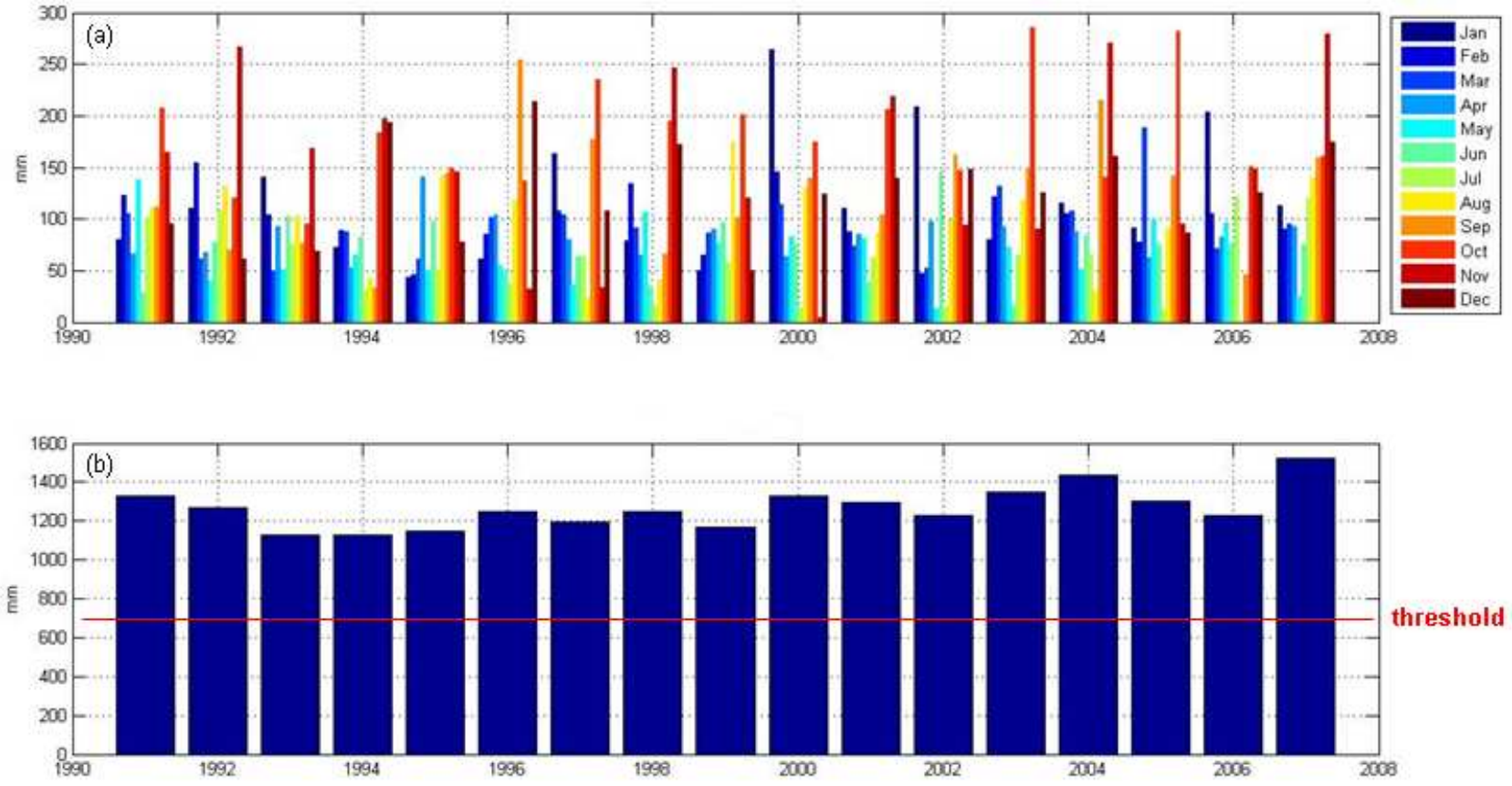
rainfall (> 700 mm.)



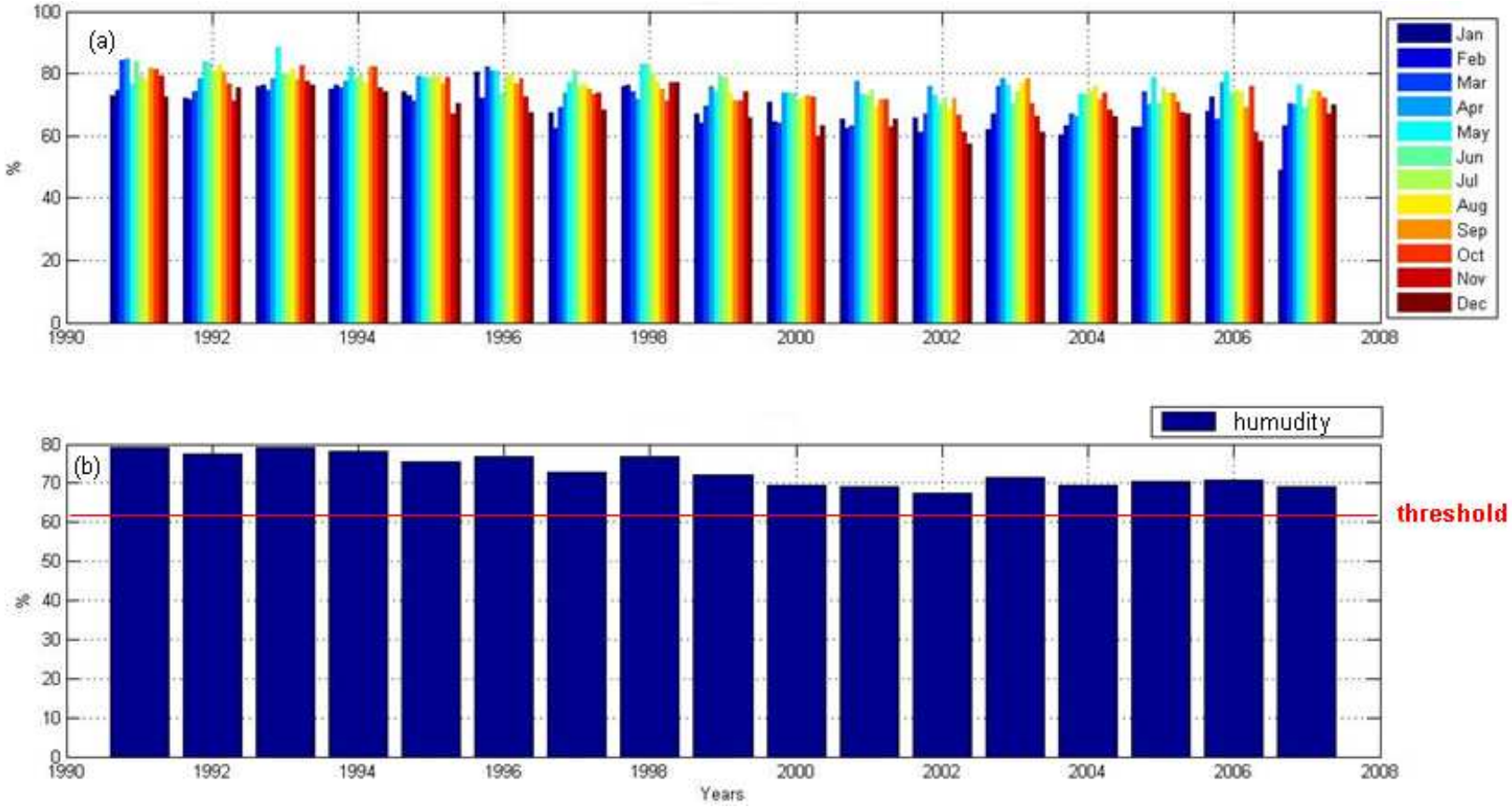
An example from a meteorological station which has the most production



precipitation



humudity


(a)
%
100
80
60
40
20
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
(b)
humudity
threshold
%
80
70
60
50
40
30
20
10
0
Years

Methodology

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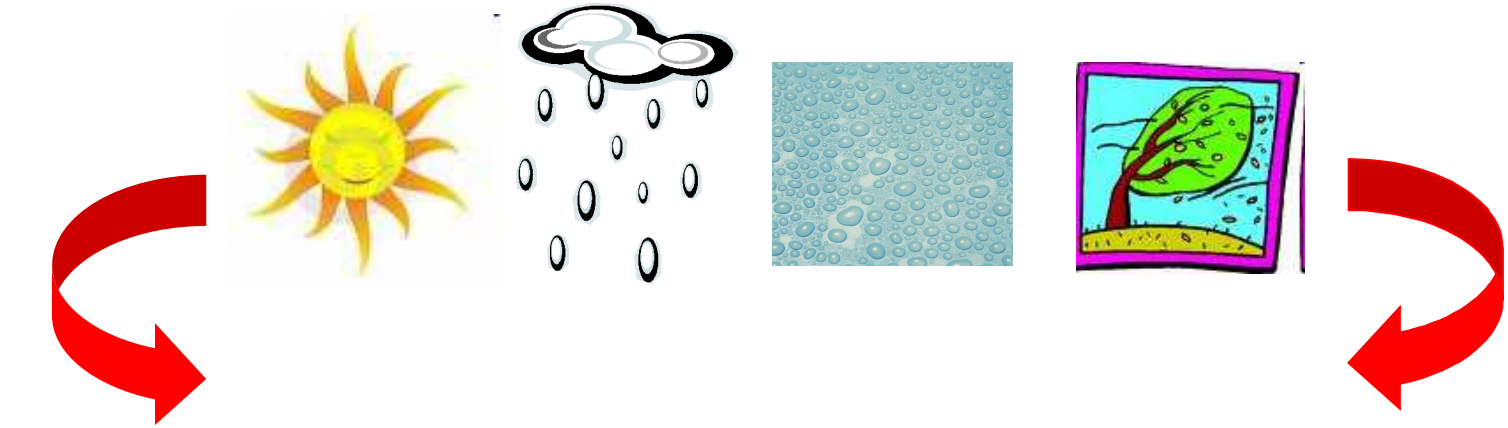
Phenology of hazelnut



Formation of flower bud | Loss of leaves | **Dormancy** | **Flowering** | Fertilization Maturity

Spring / Summer | **Autumn / Winter** | **Summer**

Flowering period

(April)

Absolute Minimum Temperature

	Samsun	Ordu	Giresun	Trabzon
1993	1	0.1	-0.2	2.6
1994	2.4	2.5	1.4	4.1
1995	0.2	0.6	3.7	2
1996	3	3.4	0.6	4.6
1997	-0.2	1.2	-1.7	2
1998	1	1.8	0.2	3.9
1999	2.8	4.2	2.4	5
2000	3.1	3.3	-1.2	5
2001	5.2	5.1	2.6	4
2002	2.7	3	3	2.9
2003	1.5	2.9	-0.6	2.2
2004	**-2.4**	**-1.4**	**-2**	**-2**
2005	0.2	1.7	0.3	2
2006	3	3.6	3.4	1.2
2007	2.7	4.6	3.6	

Yield (kg / hec)

	Samsun		Ordu		Giresun		Trabzon		
	Çarşamba	**Terme**	**Fatsa**	**Ünye**	**Merkez**	**Bulancak**	**Merkez**	**Arsin**	**Yomra**
1993	0.7	0.7	1.0	0.7	0.8	1.2	1.9	1.1	1.0
1994	2.0	2.1	2.1	1.9	2.1	2.6	2.4	3.4	2.7
1995	0.7	1.5	1.9	1.8	2.2	1.8	3.2	3.7	3.3
1996	2.2	1.5	1.4	1.3	1.5	1.6	1.9	2.2	2.0
1997	2.3	1.9	1.3	1.3	1.1	1.3	2.8	2.9	2.7
1998	2.4	2.0	2.1	1.4	3.0	2.0	2.1	3.4	2.3
1999	1.6	1.9	1.6	2.2	2.8	1.5	2.9	3.0	3.1
2000									
2001	**%74**	**%70**	**%54**	**%28**	**%82**	**%84**	**%73**	**%64**	**%75**
2002	2.4	1.3	2.0	1.9	1.8	2.9	2.4	2.5	2.6
2003	1.9	1.3	1.5	1.8	1.1	1.8	1.8	1.9	2.0
2004	**0.5**	**0.4**	**0.7**	**1.3**	**0.2**	**0.3**	**0.5**	**0.7**	**0.5**
2005	2.4	1.8	1.9	1.9	1.1	2.0	1.9	3.0	3.2
2006	2.9	2.6	2.5	1.7	0.6	2.1	2.3	2.3	2.5
2007	1.1	0.7	2.4	1.8	0.8	1.1	1.8	1.8	1.4

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Pearson correlation coefficient & simple linear regression

> % 70

			V	VI	VII	VIII	P1	IX	X	P2	XI	XII	P3	I	II	III	IV	P4	V	VI	VII	P5	
	Unit		Formation of flower bud					Loss of leaves			Dormancy			Flowering / Pollination					Fertilization / Maturity				Annual average
Tmean	°C	R_P	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	**0.682****	*n.s*	*n.s*	**0.768****	**0.748****	**0.837****
		R^2	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	**0.465****	*n.s*	*n.s*	**0.590****	**0.560****	**0.700****
Tmax	°C	R_P	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	**0.590***	*n.s*	*n.s*	**0.697****	**0.572***	**0.746****
		R^2	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	**0.348***	*n.s*	*n.s*	**0.486****	**0.328***	**0.557****
Tmin	°C	R_P	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	**0.697****	*n.s*	**0.592***	**0.764****	**0.853****	**0.858****
		R^2	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	**0.486****	*n.s*	**0.350***	**0.583****	**0.727****	**0.736****
Rainfall	mm	R_P	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*
		R^2	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*
Relative humudity	%	R_P	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*
		R^2	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*
Wind speed	m / sn	R_P	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*
		R^2	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*	*n.s*

*p<0.05

**p<0.01

R_P Pearson correlation coefficient

R^2 Simple linear regression

P1: I.Period (the average of formation of flower bud)

P2: II.Period (the average of loss of leaves)

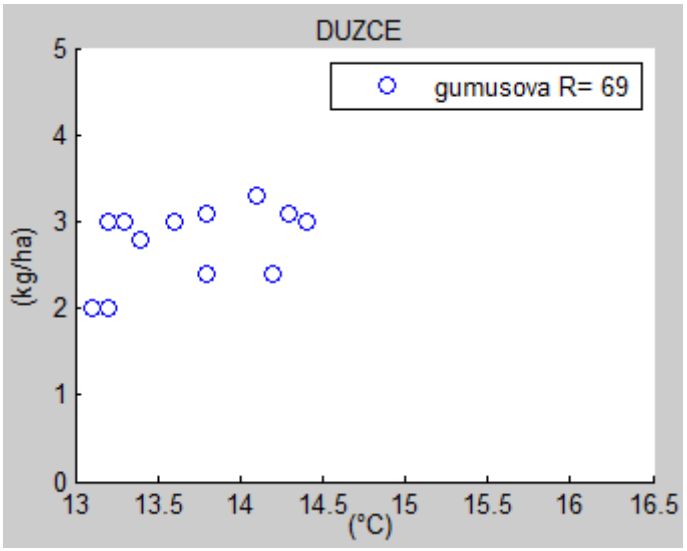
P3: III.Period (the average of dormancy)

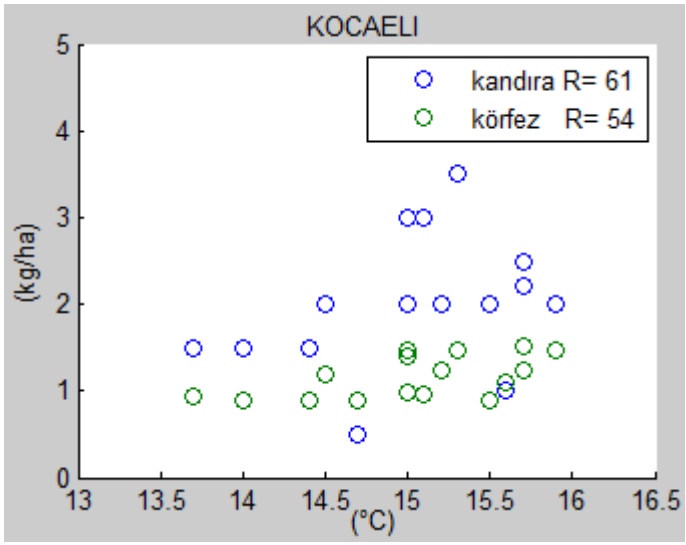
P4: IV.Period (the average of flowering / pollination)

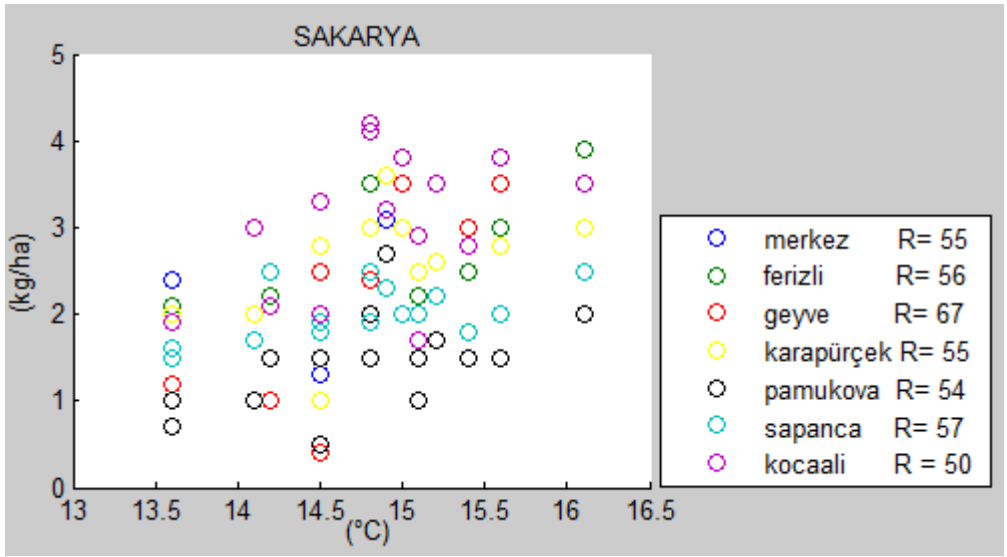
P5: V. Period (the average of fertilization / maturity)

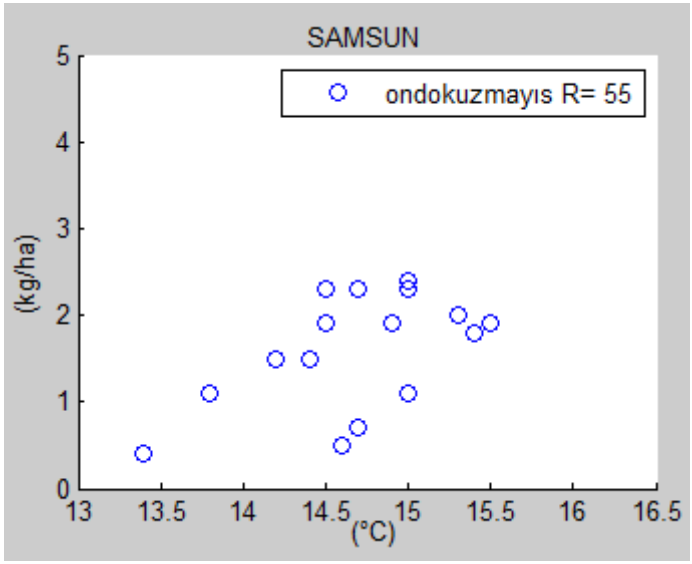
- Understanding the relationship between dependent and independent variables
- Positive or negative effect of each climatic variables

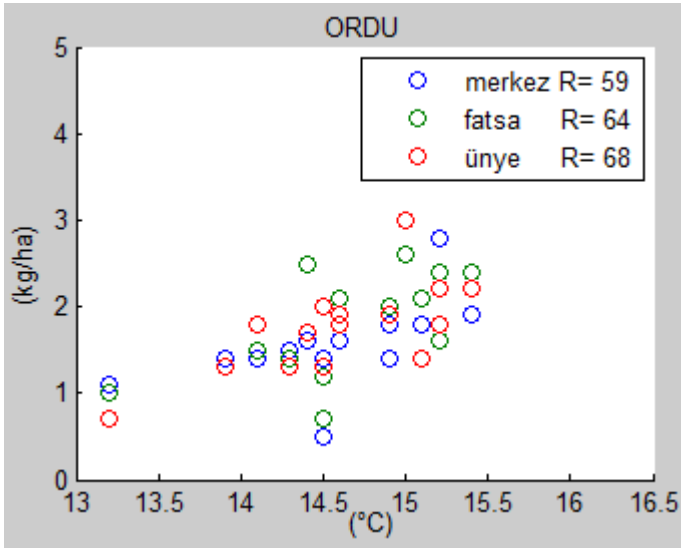
Annual mean temp & yield

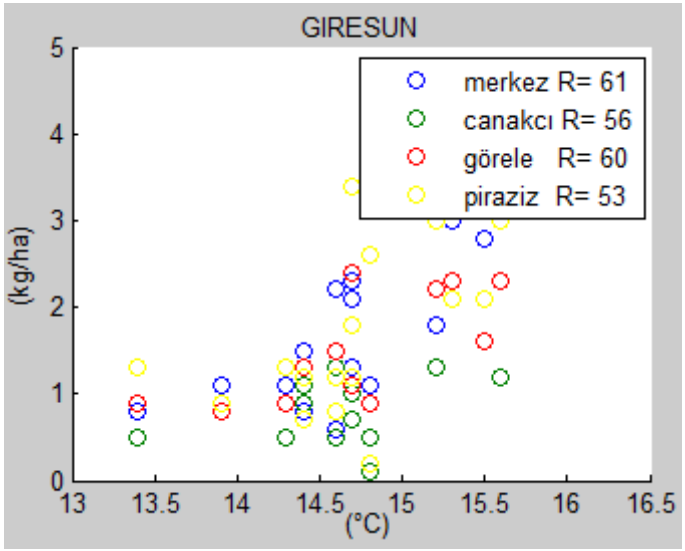


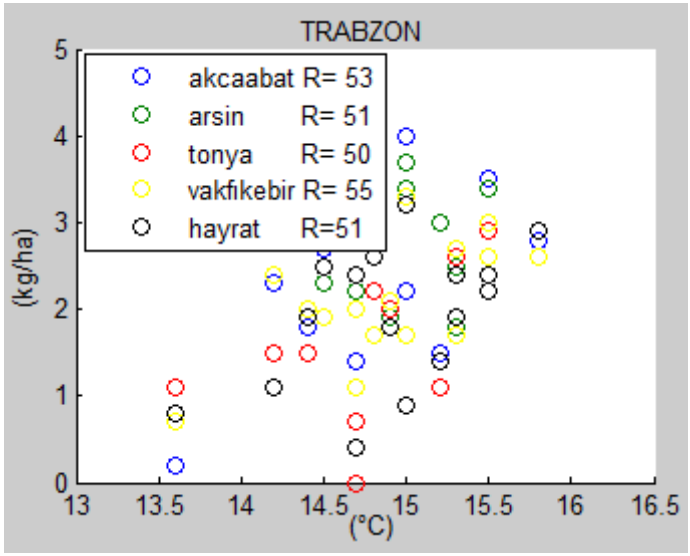





SAMSUN
ondokuzmayıs R= 55
(kg/ha)
(°C)


ORDU
merkez R= 59
fatsa R= 64
ünye R= 68
(kg/ha)
(°C)


GIRESUN
merkez R= 61
canakcı R= 56
görele R= 60
piraziz R= 53
(kg/ha)
(°C)


TRABZON
akcaabat R= 53
arsin R= 51
tonya R= 50
vakfikebir R= 55
hayrat R=51
(kg/ha)
(°C)

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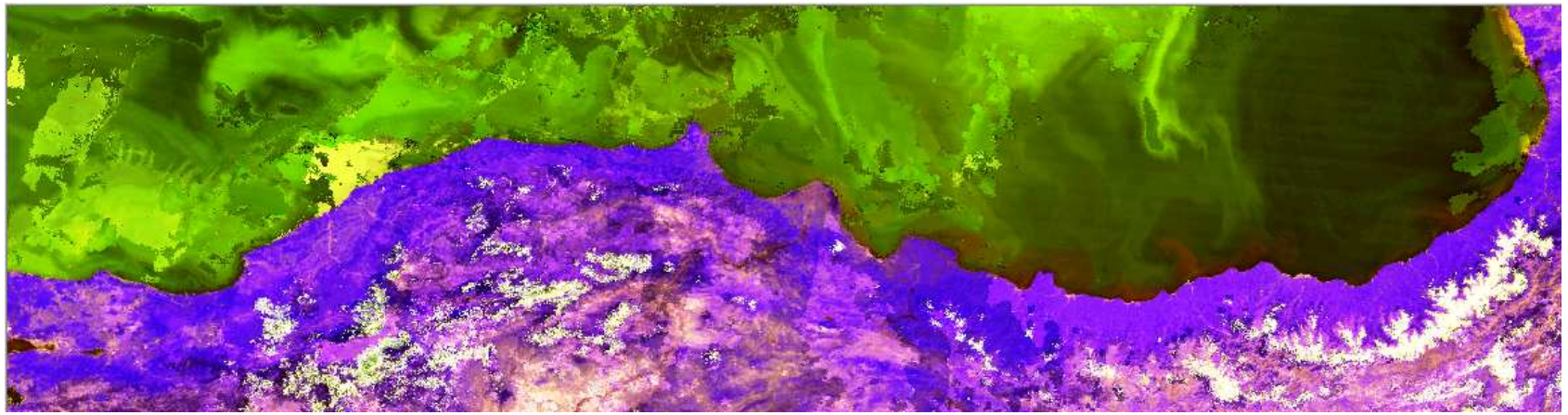
Actual cultivated area: digital image processing

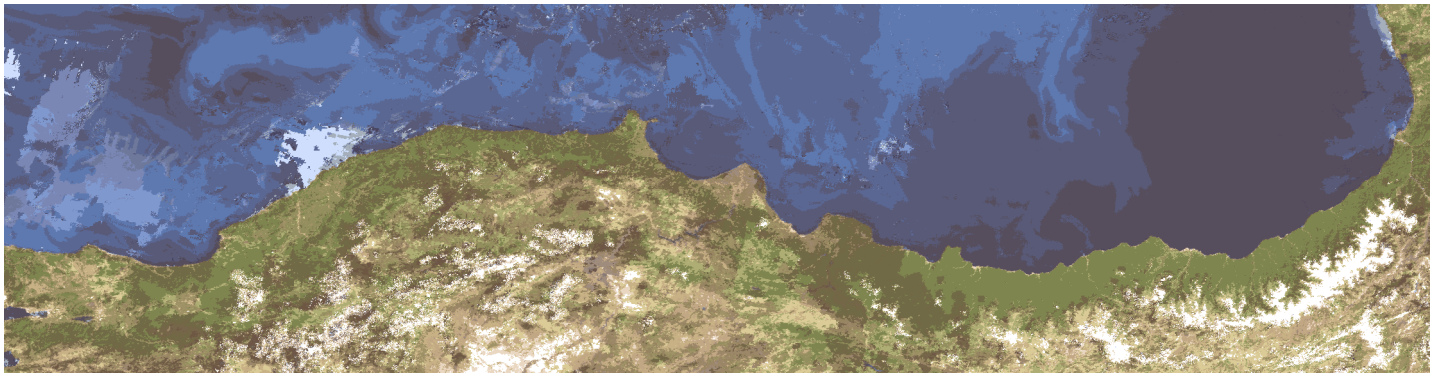
- **MODIS Terra / Aqua Surface Reflectance 8-day Global 500m. data**

- **Product description:**
- **A MOD09A1 RGB image composed of surface reflectance data measured by 7 bands**



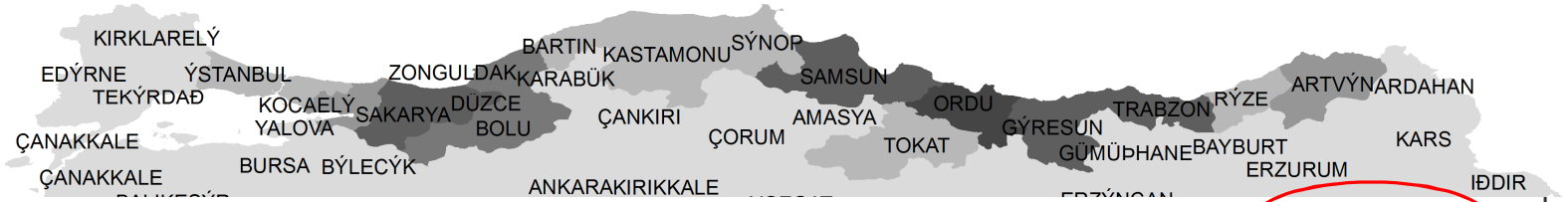
➢Referance points from Google Earth

➢Unsupervised Classification



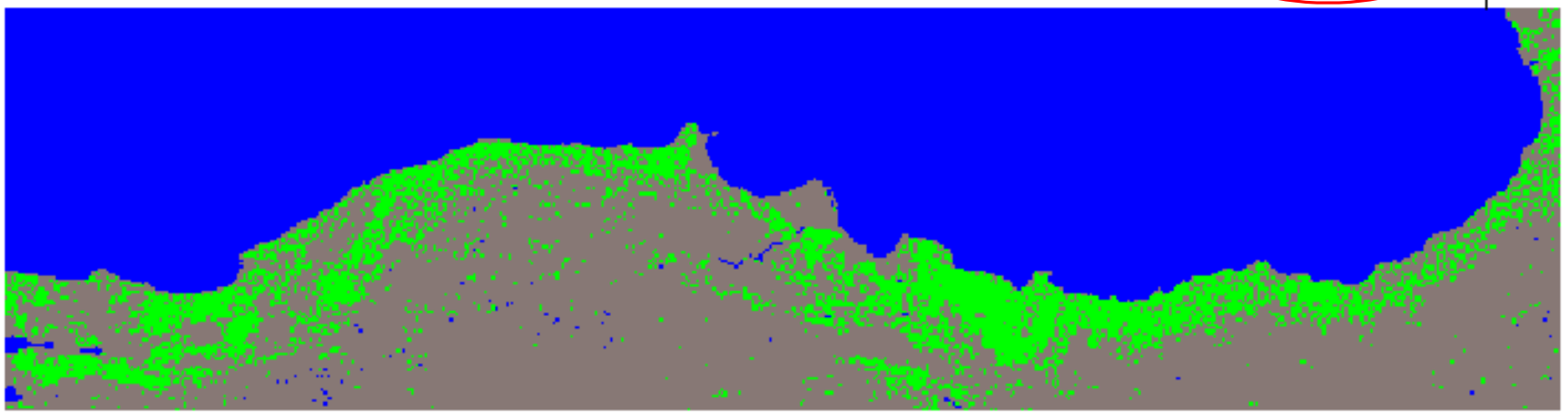
Turkish State Statistical Service 2008

519.061 ha



MODIS 2008

498.000 ha



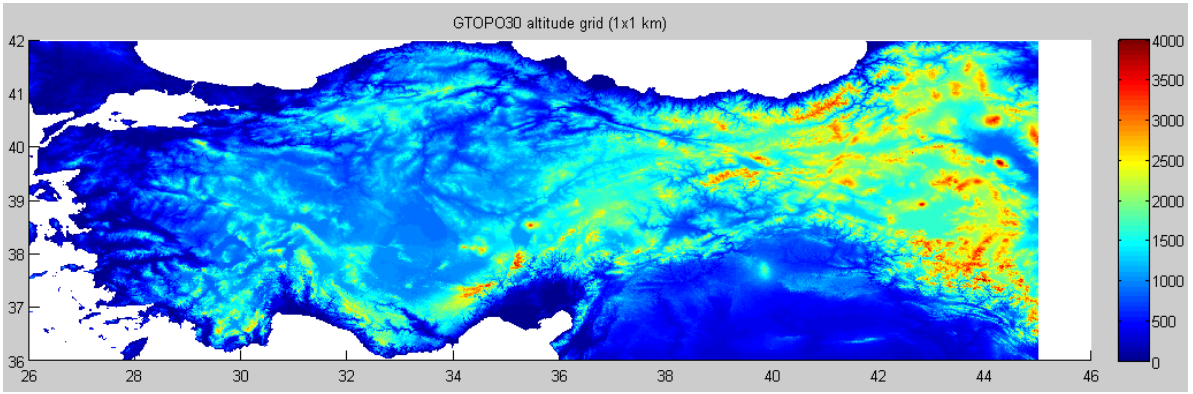
Landuse

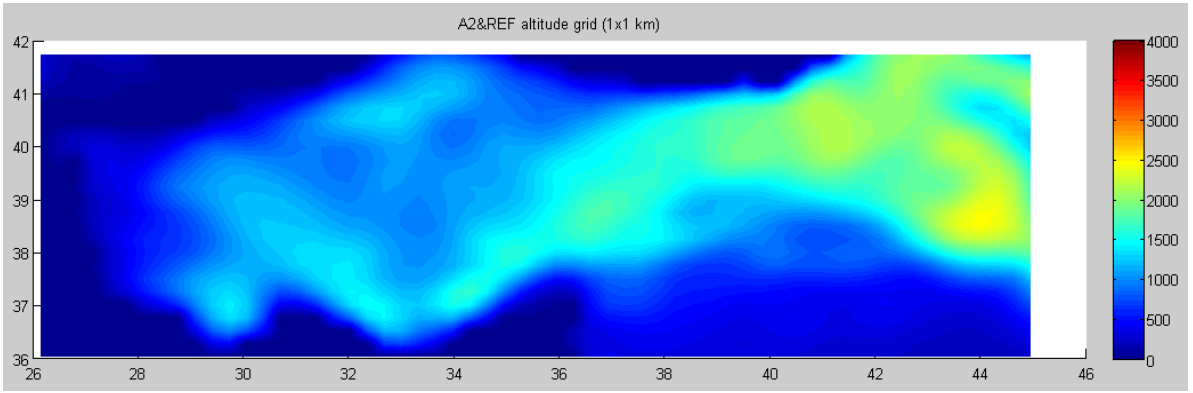
- **Sea**
- **Hazelnut cultivated area**
- **Non cultivated area**

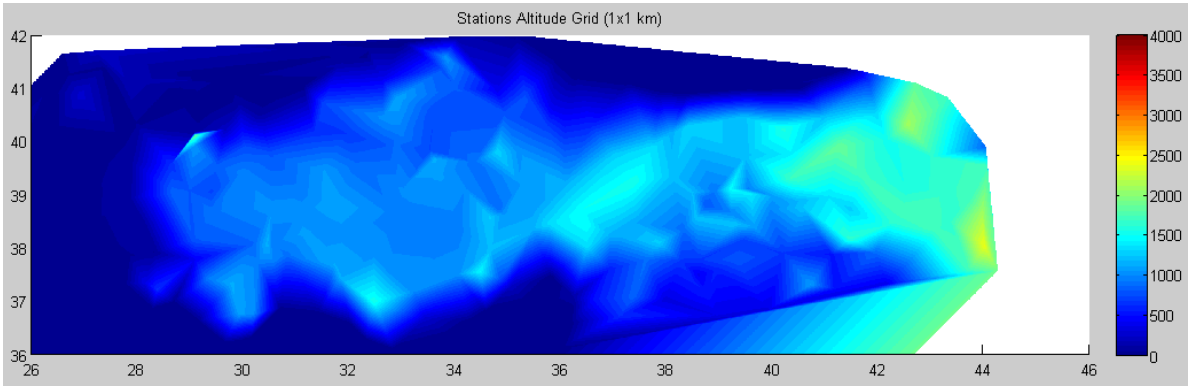
scale

50 0 Kilometre

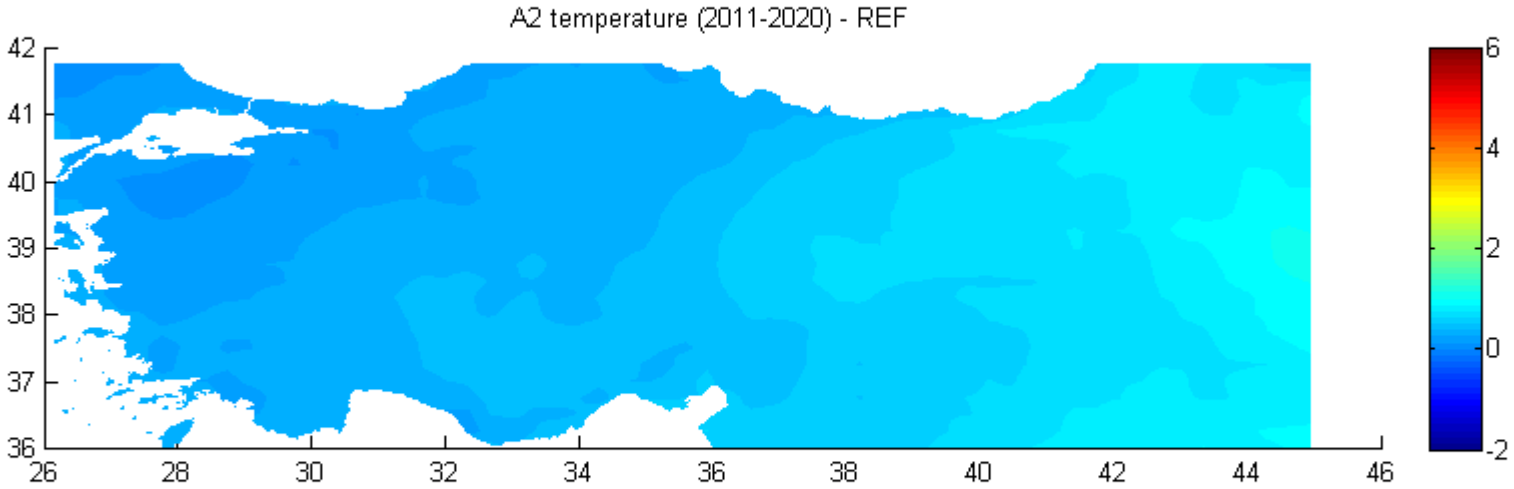
50000 0 Metre


GTOPO30 altitude grid (1x1 km)
42
41
40
39
38
37
36
26
28
30
32
34
36
38
40
42
44
46
4000
3500
3000
2500
2000
1500
1000
500
0


A2&REF altitude grid (1x1 km)
42
41
40
39
38
37
36
26
28
30
32
34
36
38
40
42
44
46
4000
3500
3000
2500
2000
1500
1000
500
0


Stations Altitude Grid (1x1 km)
42
41
40
39
38
37
36
26
28
30
32
34
36
38
40
42
44
46
4000
3500
3000
2500
2000
1500
1000
500
0

Temperature changes according to A2 scenario in Turkey


A2 temperature (2011-2020) - REF
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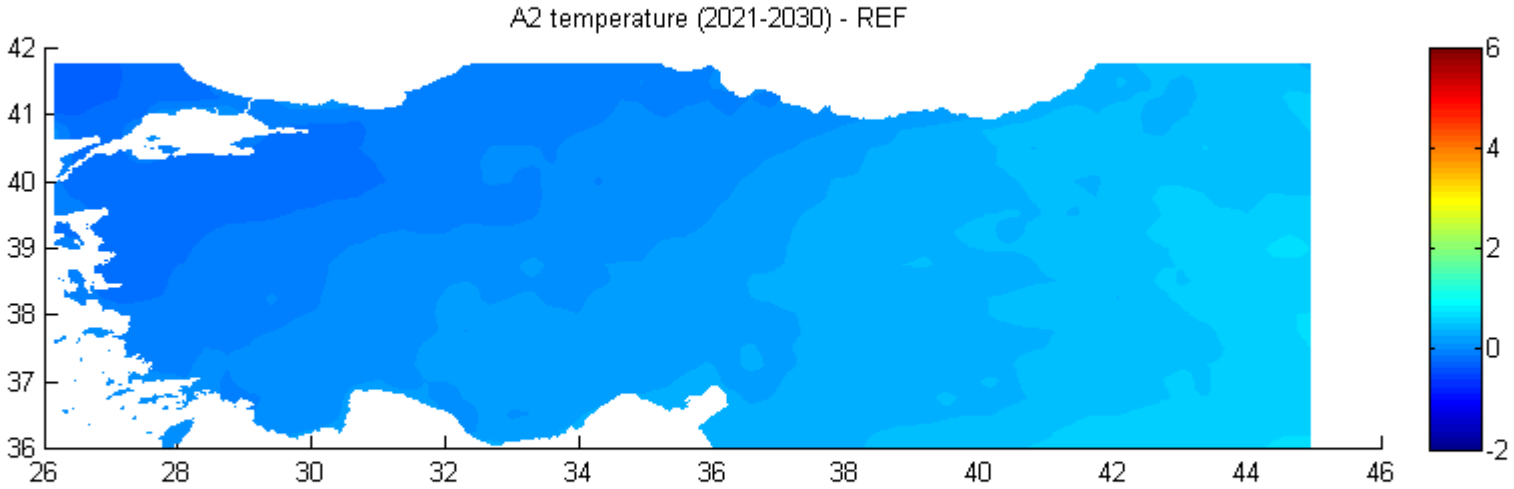
A2 temperature (2021-2030) - REF
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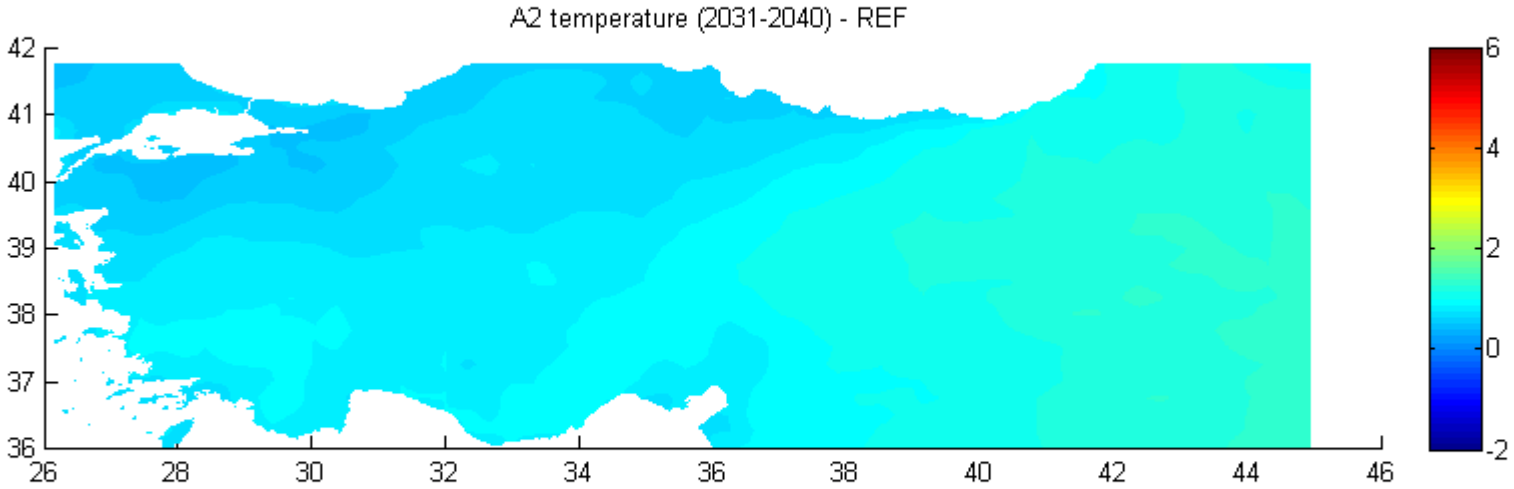
A2 temperature (2031-2040) - REF
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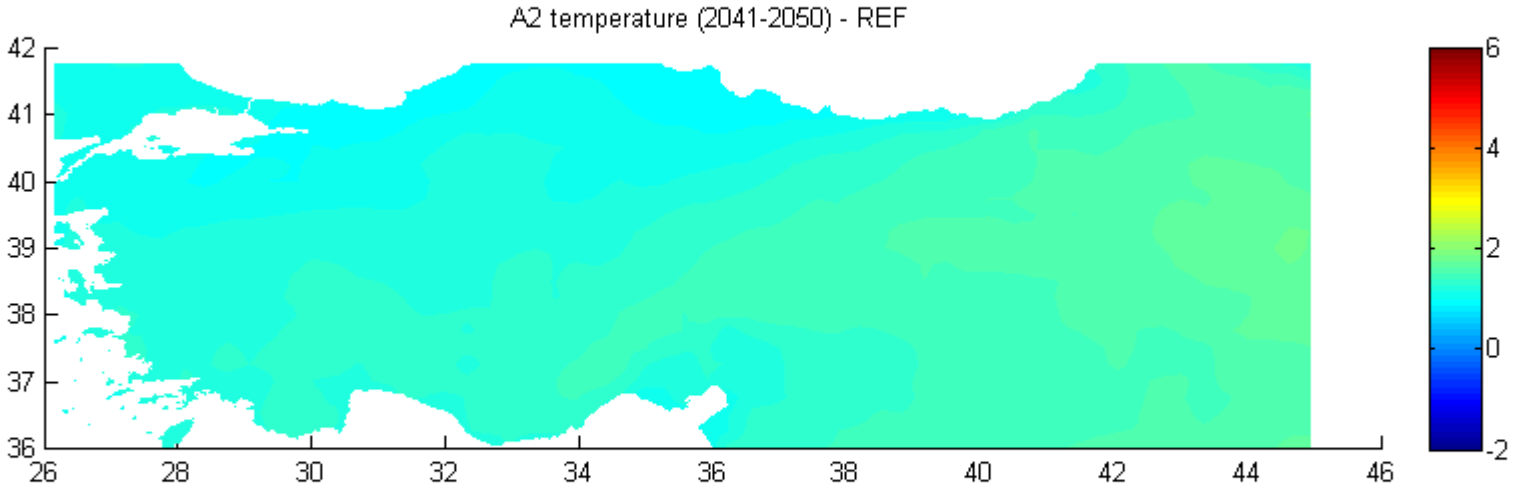
A2 temperature (2041-2050) - REF
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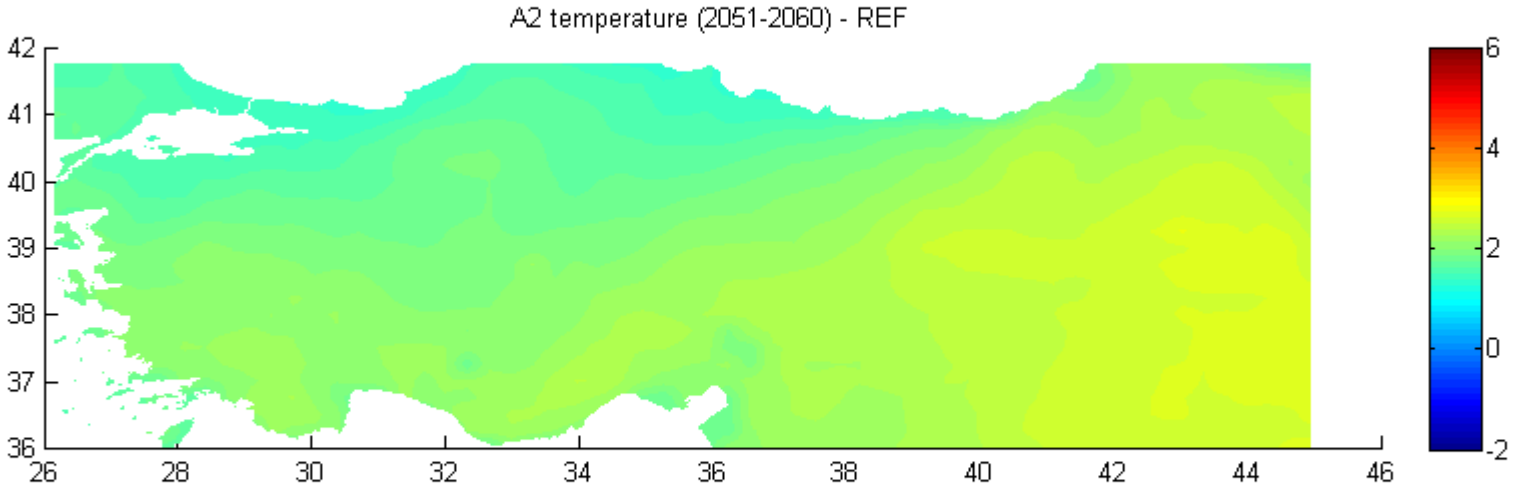
A2 temperature (2051-2060) - REF
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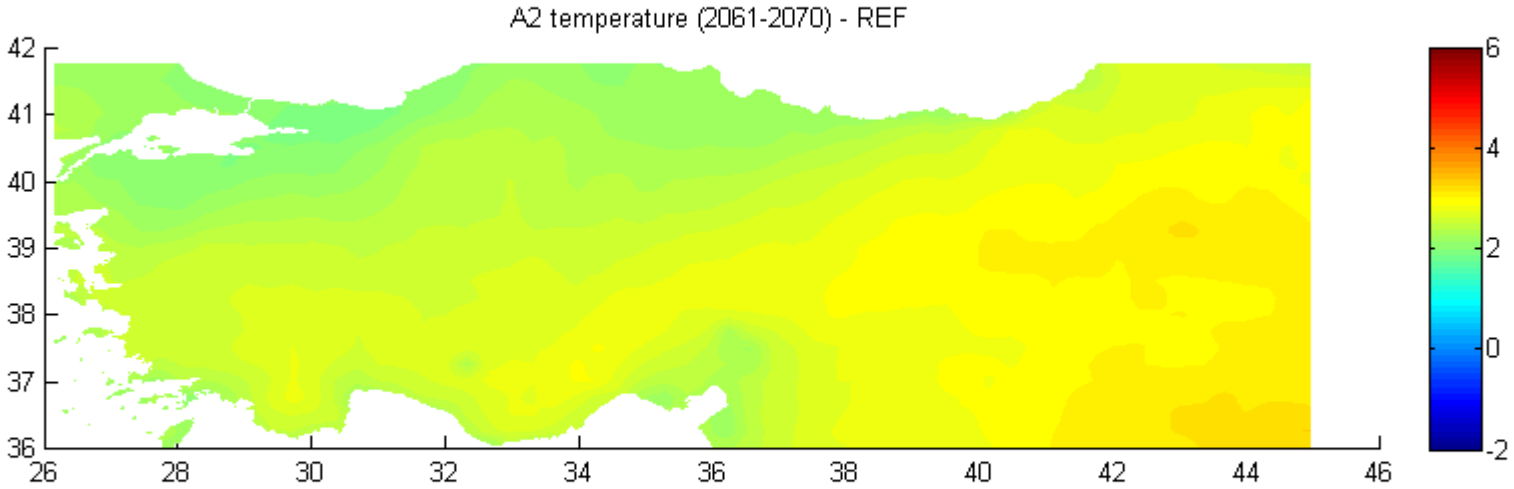
A2 temperature (2061-2070) - REF
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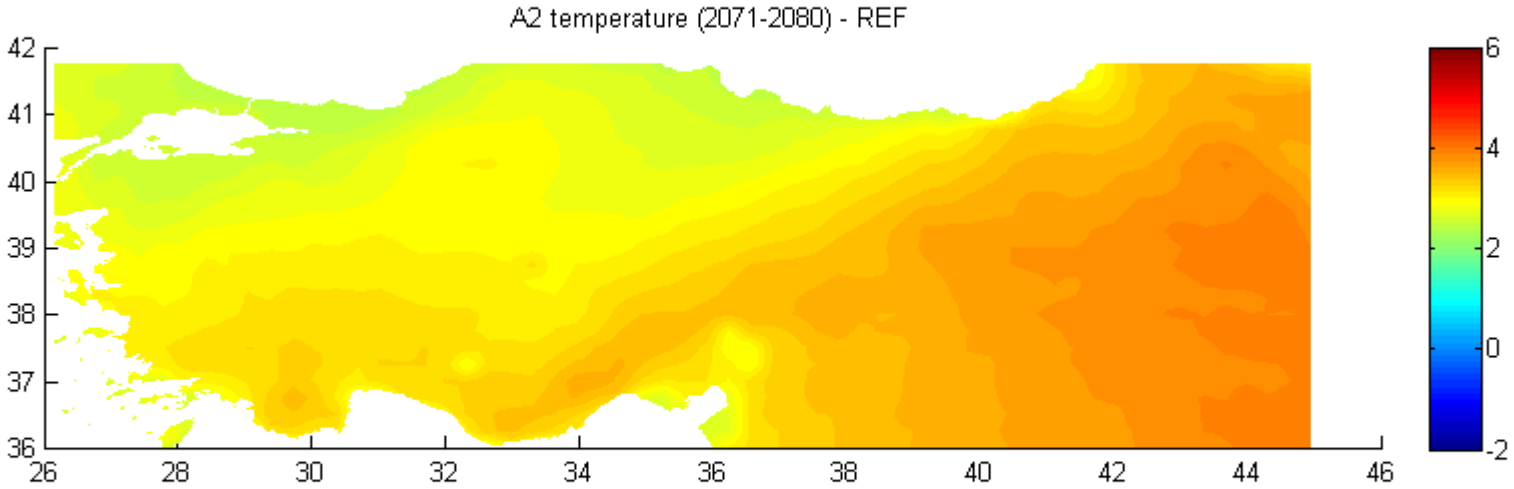
A2 temperature (2071-2080) - REF
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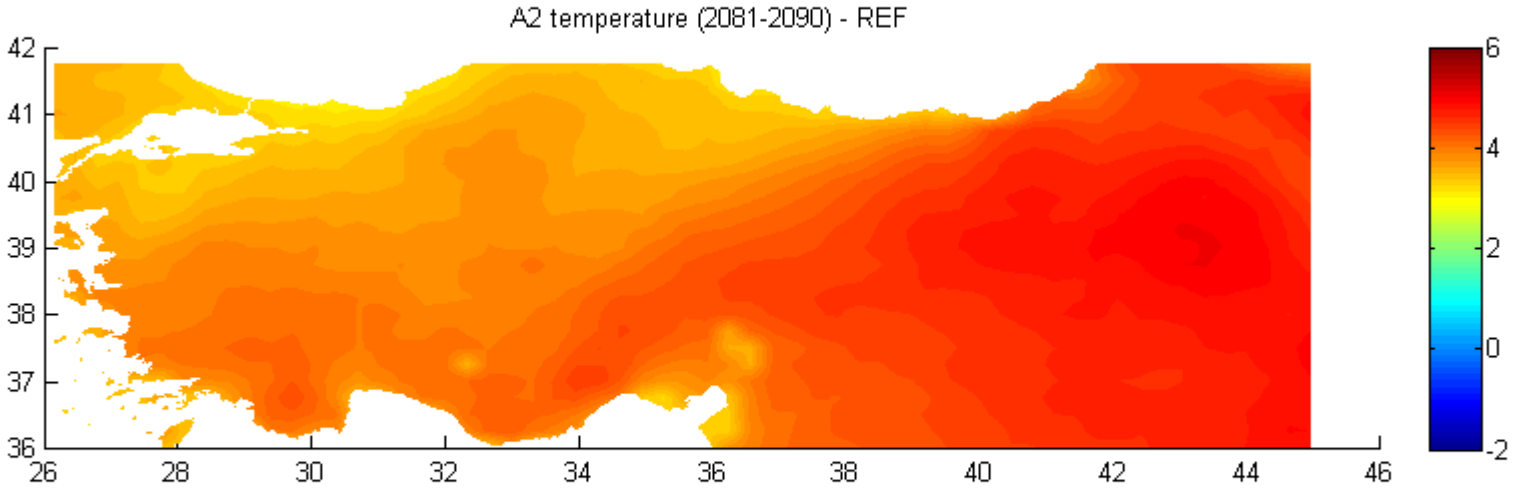
A2 temperature (2081-2090) - REF
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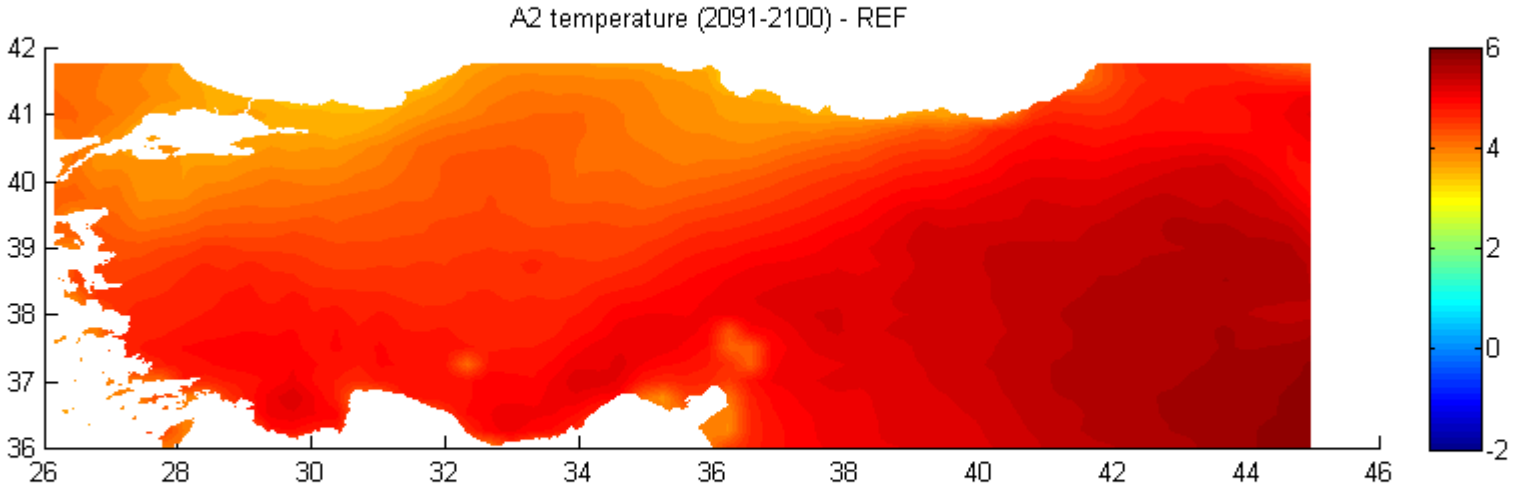
A2 temperature (2091-2100) - REF
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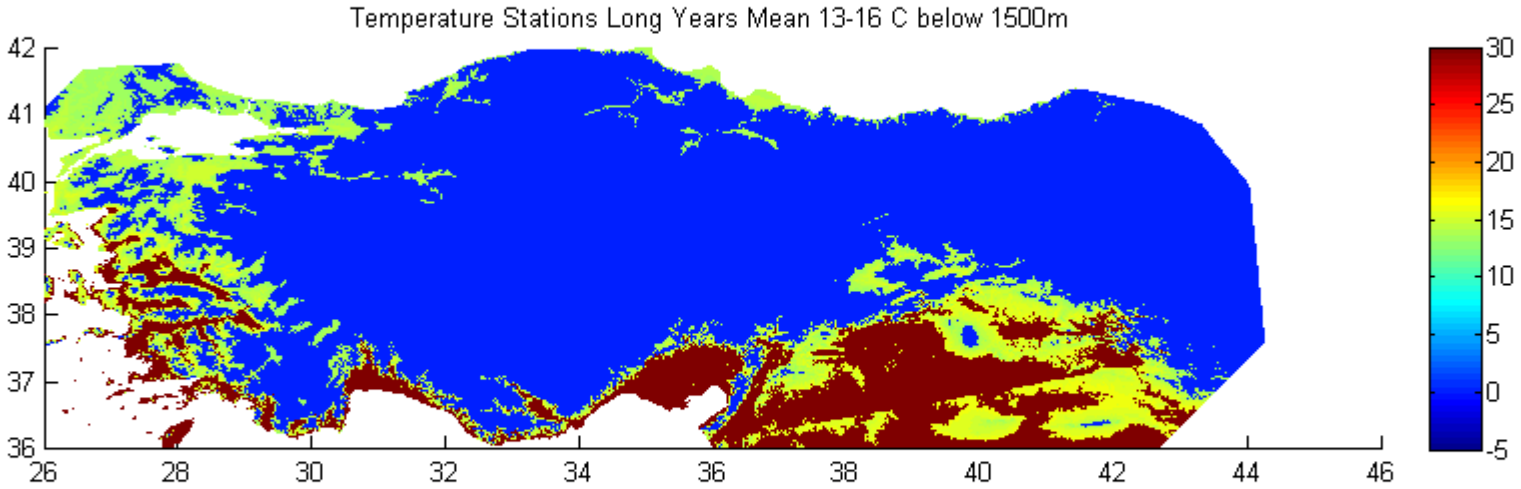
Spatiotemporal changes of hazelnut according to temperature and topography (altitude)


Temperature Stations Long Years Mean 13-16 C below 1500m
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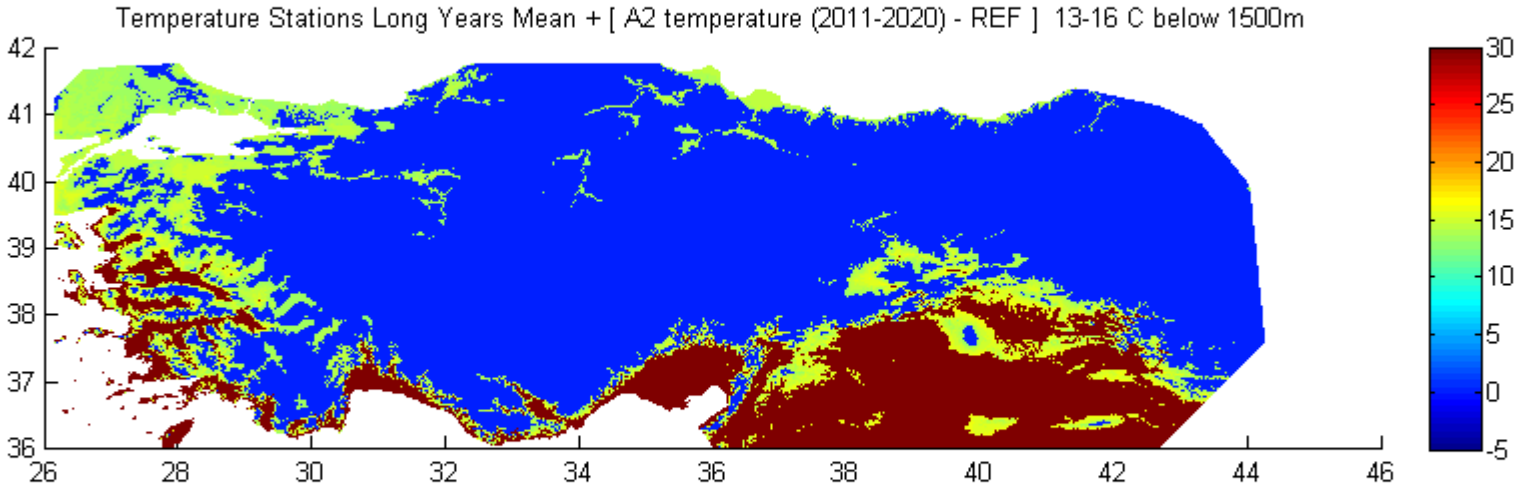
Temperature Stations Long Years Mean + [A2 temperature (2011-2020) - REF] 13-16 C below 1500m
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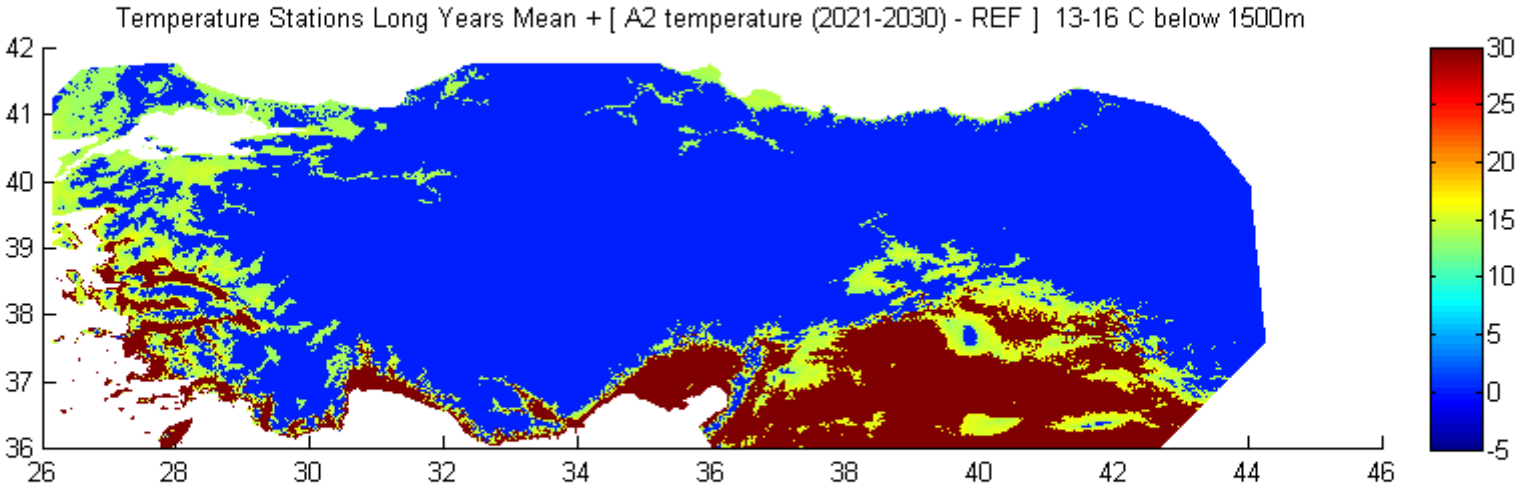
Temperature Stations Long Years Mean + [A2 temperature (2021-2030) - REF] 13-16 C below 1500m
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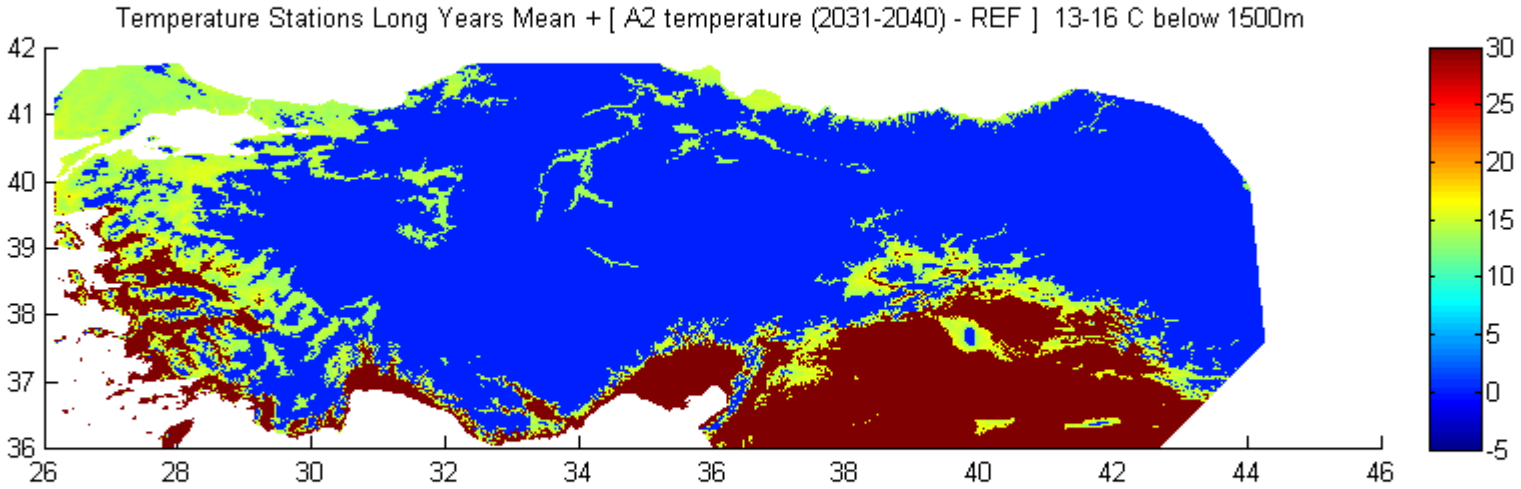
Temperature Stations Long Years Mean + [A2 temperature (2031-2040) - REF] 13-16 C below 1500m
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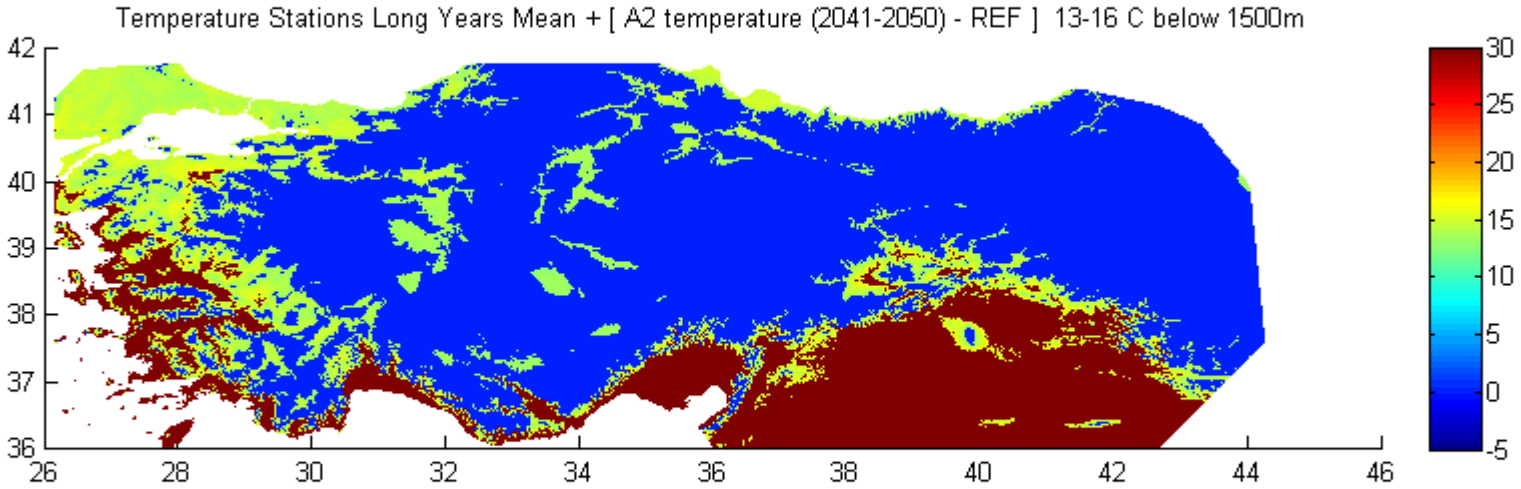
Temperature Stations Long Years Mean + [A2 temperature (2041-2050) - REF] 13-16 C below 1500m
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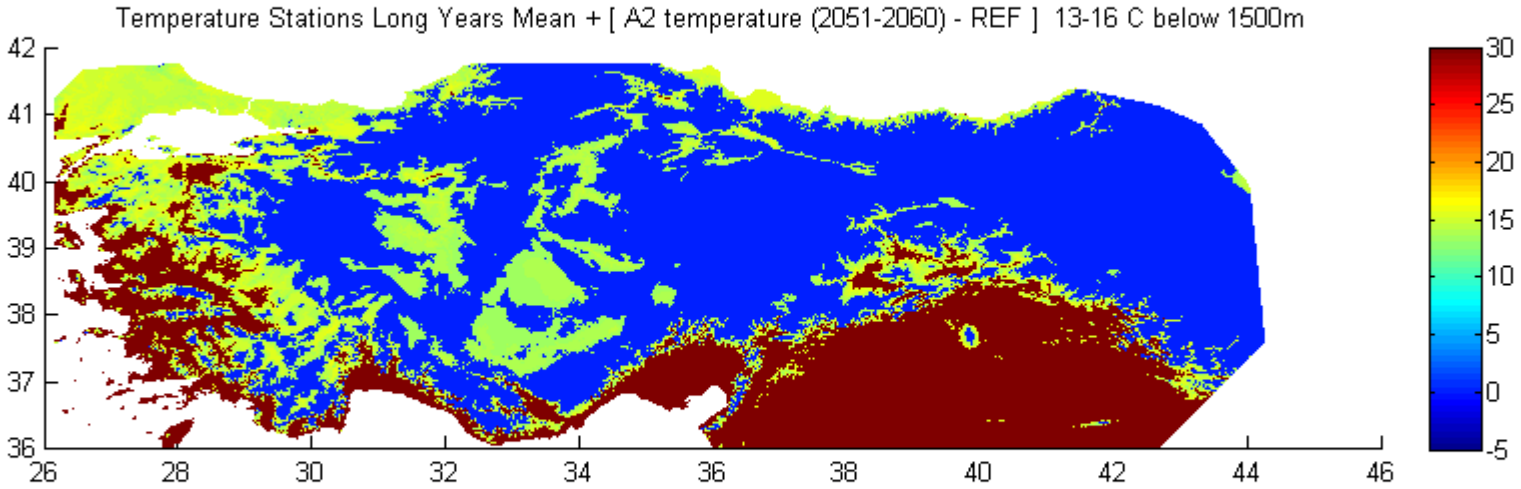
Temperature Stations Long Years Mean + [A2 temperature (2051-2060) - REF] 13-16 C below 1500m
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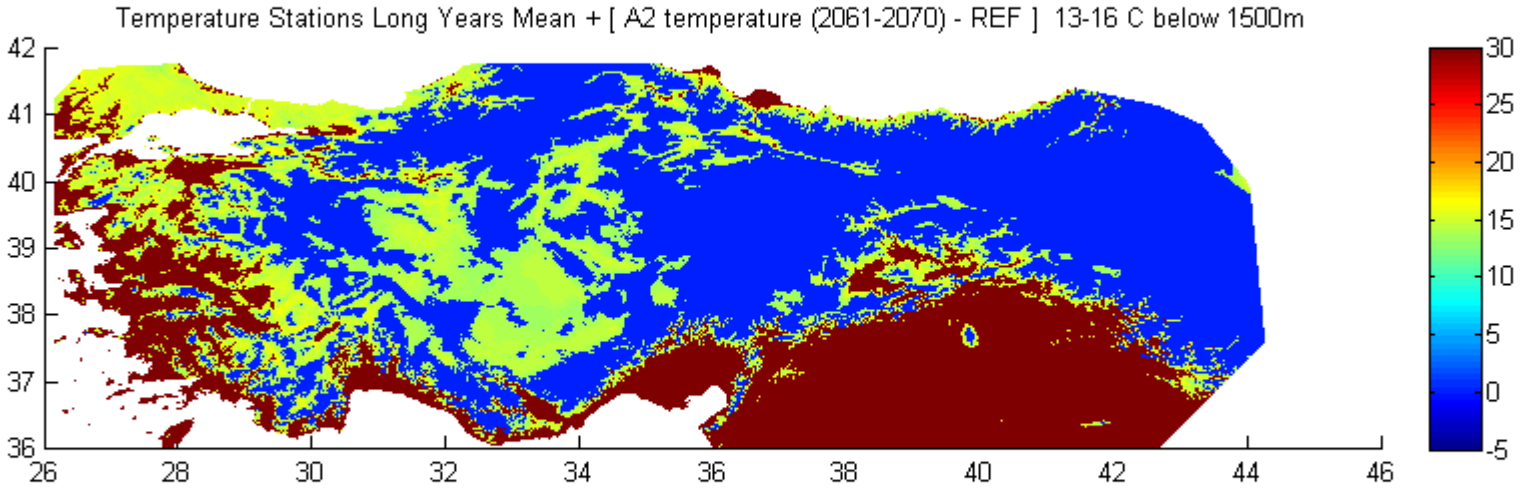
Temperature Stations Long Years Mean + [A2 temperature (2061-2070) - REF] 13-16 C below 1500m
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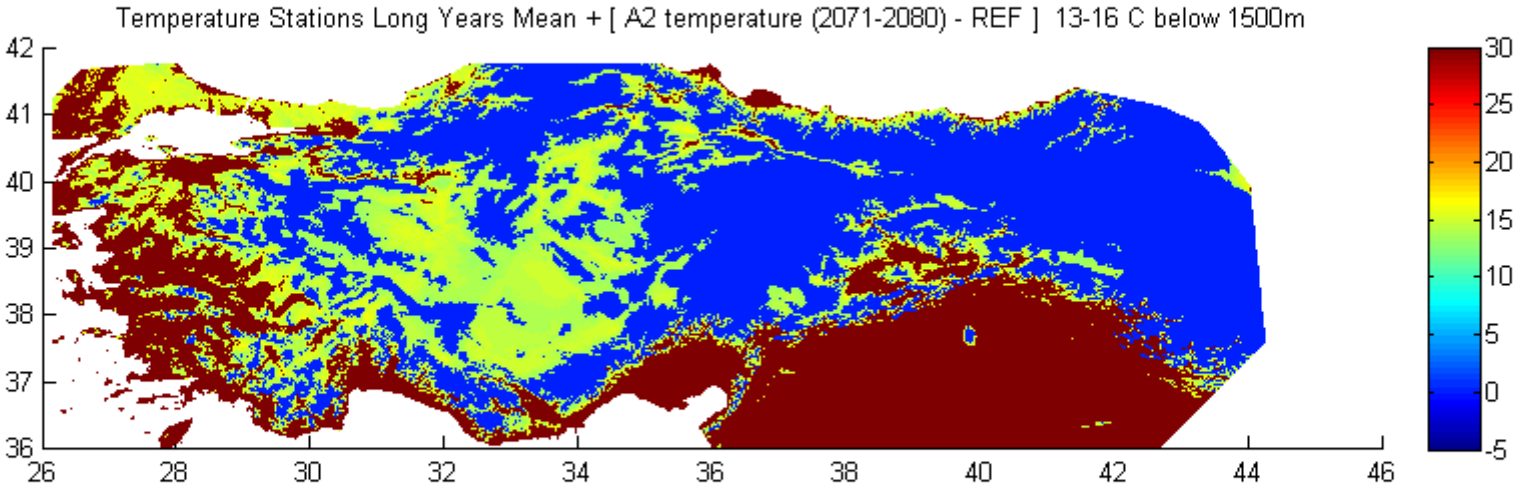
Temperature Stations Long Years Mean + [A2 temperature (2071-2080) - REF] 13-16 C below 1500m
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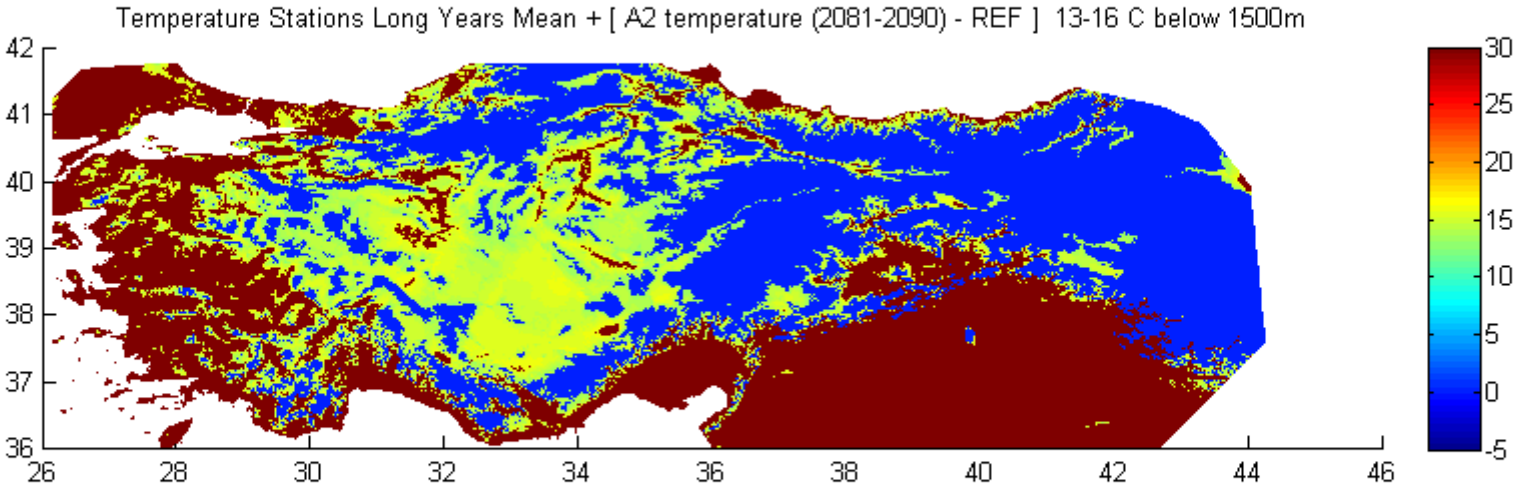
Temperature Stations Long Years Mean + [A2 temperature (2081-2090) - REF] 13-16 C below 1500m
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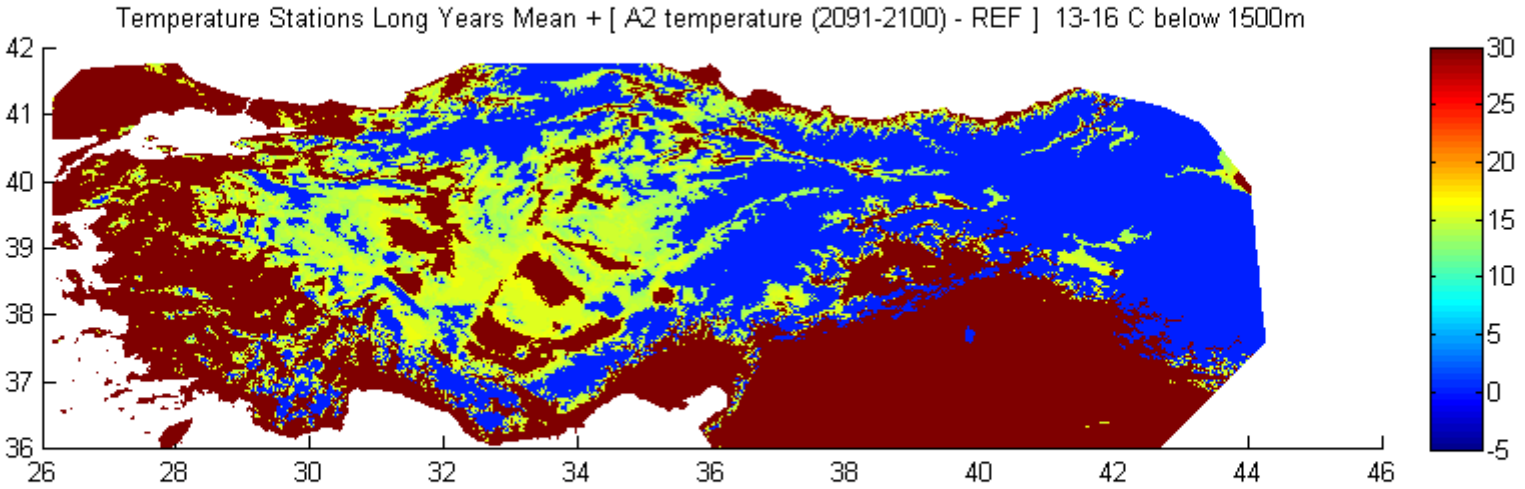
Temperature Stations Long Years Mean + [A2 temperature (2091-2100) - REF] 13-16 C below 1500m
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results

- ✓ Temperature is the most important climate variable on hazelnut yield.
- ✓ Extreme events like as frost has dramatic effects on yield. But the frequency of these are rare and it is not easy to establish scientific approach with this data.
- ✓ A temperature increase up to 6 ºC in the region over the next 90 years was identified depending on the future climate scenarios. And so it is concluded that the temperature change may cause horizantal and vertical movements of hazelnut farming areas.
- ✓ Taking this conclusion into account, it is predicted that hazelnut cultivation in the coastal zone of 0-250 meters height can be negatively affected and areas over 1500 meters height which are not suitable for farming today can become favorable for hazelnut planting due to vertical area changes.