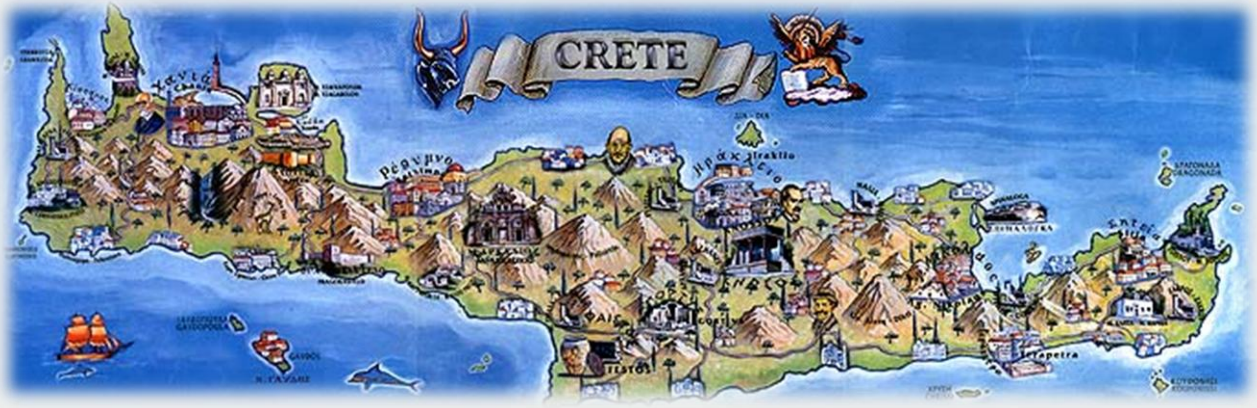
Present and future responses of Growing Degree Days for Crete Island in Greece



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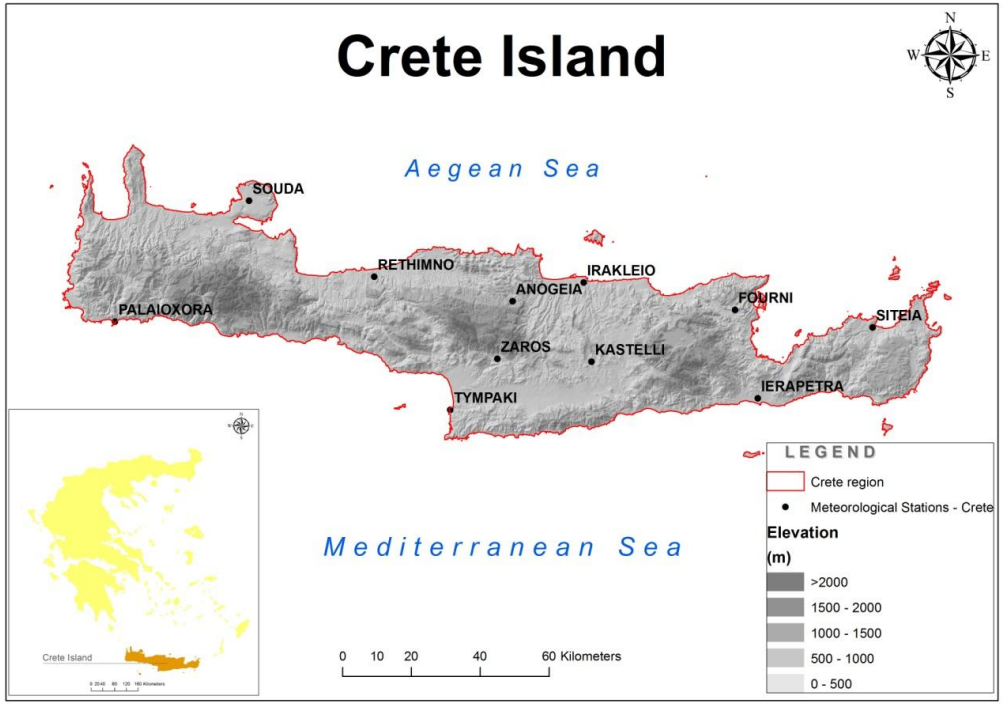
Introduction

- Climate affects practically all the physiological processes that determine plant life
- Major challenge and objective of the agricultural science → Prediction of the occurrences of specific physical and biological events
- Phenology → Study the flowering of plant species → Temperature and heat units → most important factors that affect the processes leading to flowering
- Growing Degree Days → Determination of heat requirements in the developing faces of the plants
- Understanding the flowering season development – forecasting when flowering will occur

Study area

- Crete Island → South Greece
- Population: 623.065
- Area: 8.342 km²
- Mean annual rainfall: 822 mm
- Mean air temperature: 17.2 ºC



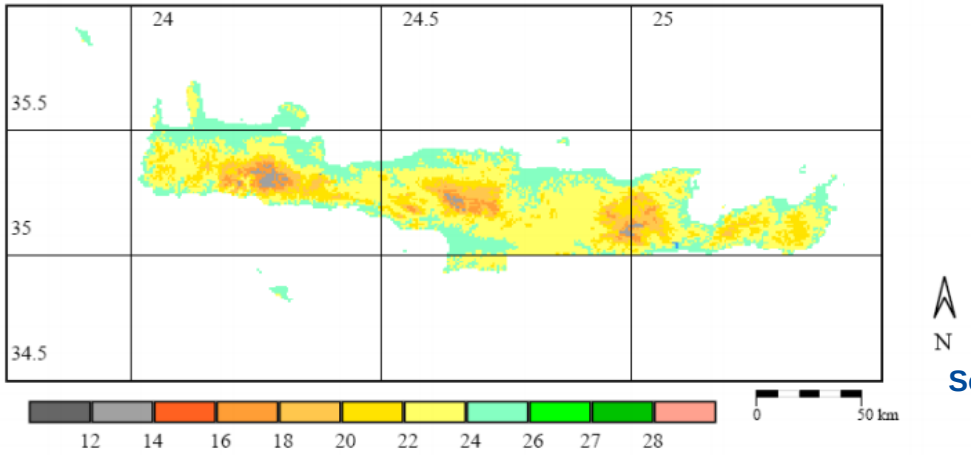


Figure 4. Map of air temperature (°C) for Crete for summer (June, July and August) during the normal period 1961 – 1990 (resolution: 1 km).

Source: Matzarakis and Nastos 2011

Aim

- **Agriculture**
  - → **Main production and economic activity**
  - → **Knowledge of present and future variation of GDD is mandatory**

- **Significant part of the local population is employed fully or partly in the agriculture section**

- **Farming and manufacturing activities based on the agriculture activity**
  - → **emerging need for a research**
  - → **information and adapting systems**
  - → **main local cultivations**

Methodology

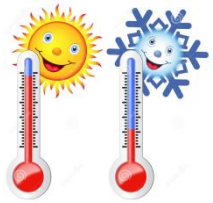
- **Assessment and mapping of future responses of the Growing Degree Days:**
  1. **Statistical analysis**
  2. **Downscaling**
  3. **Spatial interpolation**
  4. **Multi-linear regression techniques**
  5. **Combination of statistical and dynamical approach**

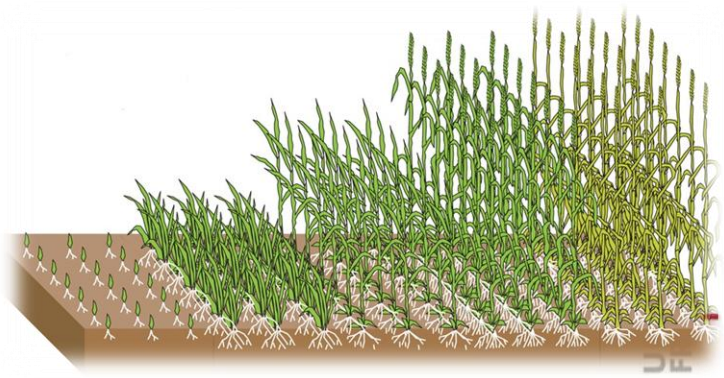
- **<u>Future periods:</u> 2021-2050 and 2071-2100**

- **<u>Future scenarios:</u> IPCC Emission scenarios A1B and B1**

- **<u>Future data (simulations):</u> ENSEMBLES Project**

→ **Maximum – Minimum air temperature**
→ **Main cultivations and characteristics**





Material

M. S.	Lat. (°)	Long. (°)	Elevation (m)	Period
Souda	35.54	24.1	106.4	1981-2000
Irakleio	35.32	25.17	68.3	
Ierapetra	35.01	25.72	24.2	
Siteia	35.19	26.09	25	
Rethimno	35.34	24.5	118	
Tympaki	34.99	24.74	33.7	
Palaioxora	35.23	23.68	25	
Anogeia	35.28	24.95	823.7	
Fourni	35.25	25.66	500	
Kastelli	35.12	25.2	350	
Zaros	35.13	24.90	322	

Main Cultivations	Latin name	GDD units to maturity	References
Olive	*Olea europaea*	900+	Miller et al. (2001)
Grape vine	*Vitis vinifera*	1210-1844	Köse (2014)
Tomato	*Solanum lycopersicum*	1000-2000	Raes et al. (2010)

Methodology

- **Climatological data:**
  - → **Reference period data**
    - Daily values of T_{max} and T_{min}
  - → **Future data (simulations)**
    - Daily output simulations from 6 Regional Climate Models

- **Estimation of the Growing Degree Days:**

$$GDD = \left(\frac{T_{max} + T_{min}}{2}\right) - T_{base}$$

Where:

T_{max} : maximum air temperature (°C)

T_{min} : minimum air temperature (°C)

T_{base} : temperature below which the process of growth does not progress (current study: 10 °C)

Methodology

- **Downscaling for mapping**
  - → **Combination of statistical and dynamical downscaling**
  - → **Statistical approach: multi-linear regression technique**

$$POINT_{value} = b_o + b_1 h + b_2 slp + b_3 X + b_4 Y + b_5 DistWat$$

Where:

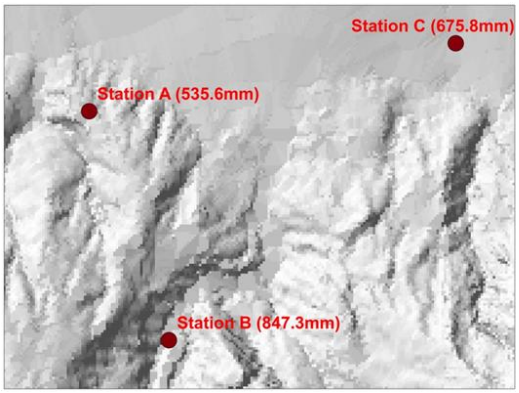
GDD_{value} :	dependent variable in a certain sample point
b_o :	constant
$b_1 \ldots b_5$:	represent the coefficients obtained for each independent variable
h :	elevation (m)
slp :	slope (%)
X :	*l*ongitude (°)
Y :	*l*atitude (°)
DistWat :	*d*istance from a body of water (sea or lake - km)

→ **Dynamical approach:**

ArcGIS → Ordinary Kriging → 1x1km grid → each sample point: unique value

- **Period: April - October**
- **Statistical Analysis (measured data, scenarios)**

Methodology

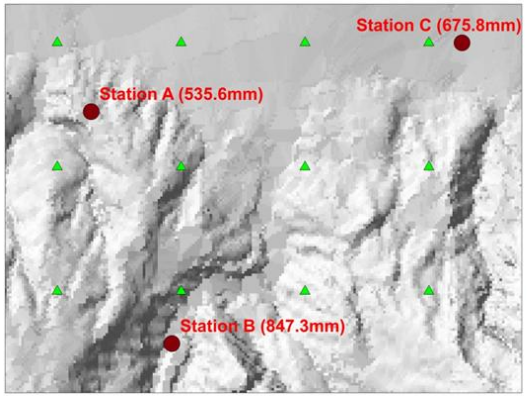


Existing network of stations

Statistical approach

Meteorological stations → Multi-linear regression

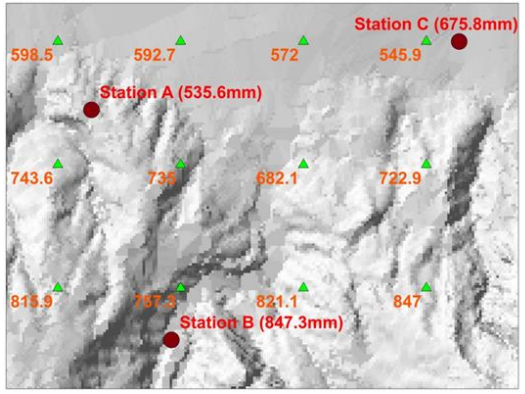
$$POINT_{value} = b_o + b_1 h + b_2 slp + b_3 X + b_4 Y + b_5 DistWat$$



Creation of 1x1km Grid of points through ArcGIS

Dynamical approach

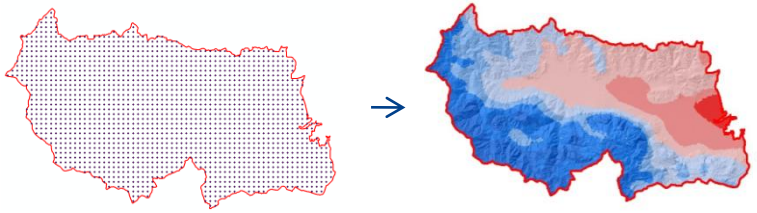
ArcGIS → 1x1km Grid creation



New grid points receive a unique value through the multi-linear regression

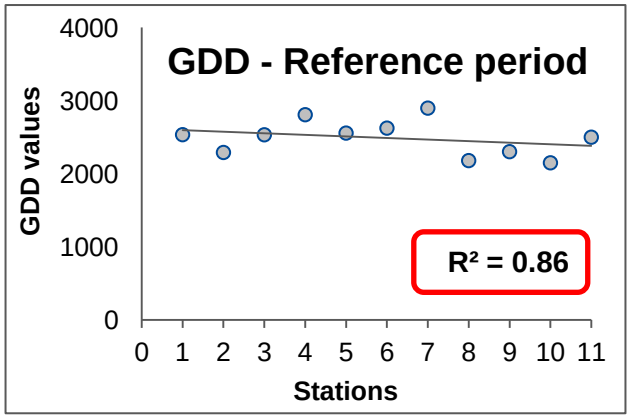
Spatial Interpolation

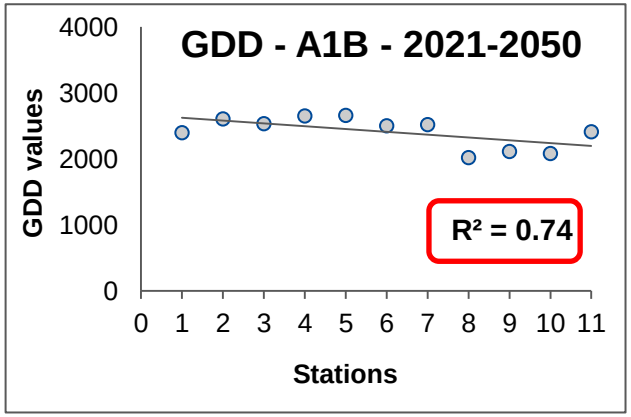
Ordinary Kriging → unique sample point: value

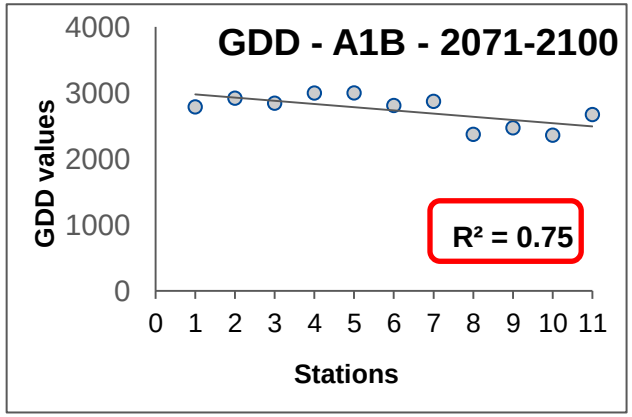


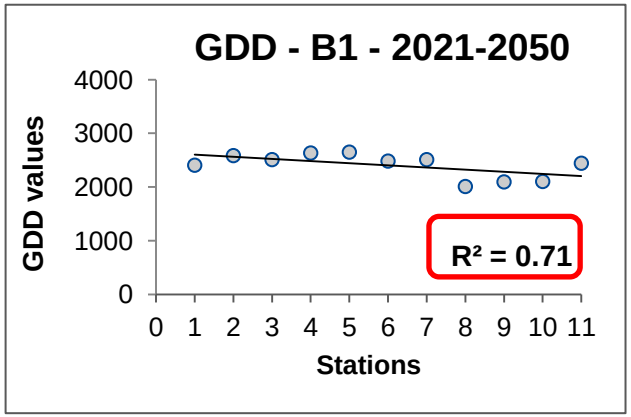
Results - stations

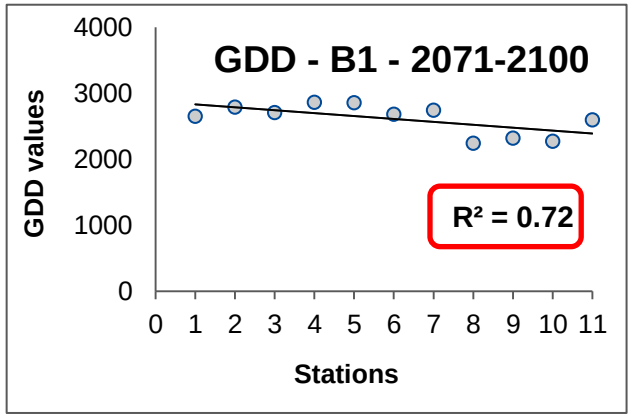
Multi-linear regression (11 stations)



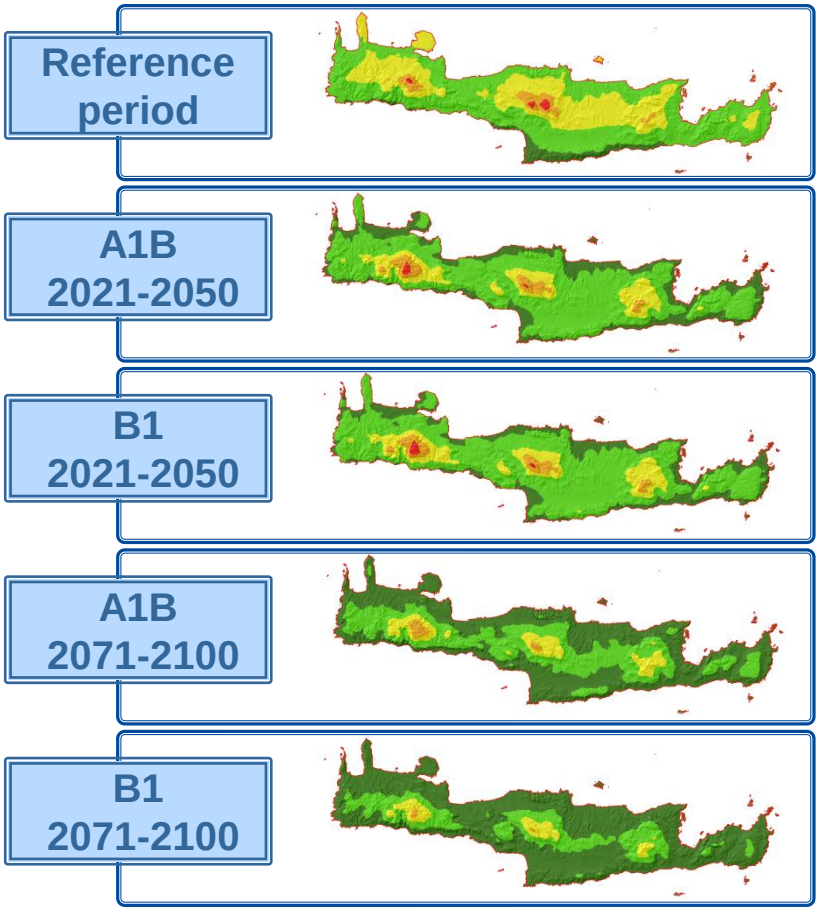








Results and Discussion



GDD (°C)

0 - 500

1501 - 2500

Main Cultivations	GDD units to maturity
Olive	900+
Grape vine	1210-1844
Tomato	1000-2000

- S… therea…
- …its
- → 2nd perio… …0 – 2800 units
- Almost all the existing cultivations will reach maturity units
- Areas near coastline will face the most favourable conditions

Period	GDD Current	2021-2050		2071-2100	
		A1B	B1	A1B	B1
Apr - Sep	2196	1947	1940	2231	2126
Apr - Oct	2496	2269	2260	2602	2476
Apr - Nov	2663	2488	2479	2857	2708

Discussion and conclusions

- **Future increase of growing degree days**
  - → **Water resources can benefit**
  - → **Avoiding overexploitation of aquifers**
  - → **Better soil quality**

- **Existing cultivations can reach maturity earlier**
  - → **Possible transfer of the cultivation period (e.g. Apr-Oct → Apr-Sep)**
  - → **New, more pretentious but also profitable cultivations can be introduced**

- **Complex topography**
  - → **Will act as an inhibitor towards the sustainable development and expansion of the existing crops onto higher altitudes**

Conclusions and Outlook

- Assess the future variations of the GDD in combination with future responses of precipitation

- Application of the current study:
  - → Helping hand for all the stakeholders (farmers, civil authorities, etc.)
  - → Adjust their systems
  - → Manage their agricultural procedures

- In order to prevail against the effects of the climate change


Vielen Dank
Thank you
Ευχαριστώ πολύ