Adagio

Climate change, vulnerability, and adaptation in agriculture – the situation in Italy

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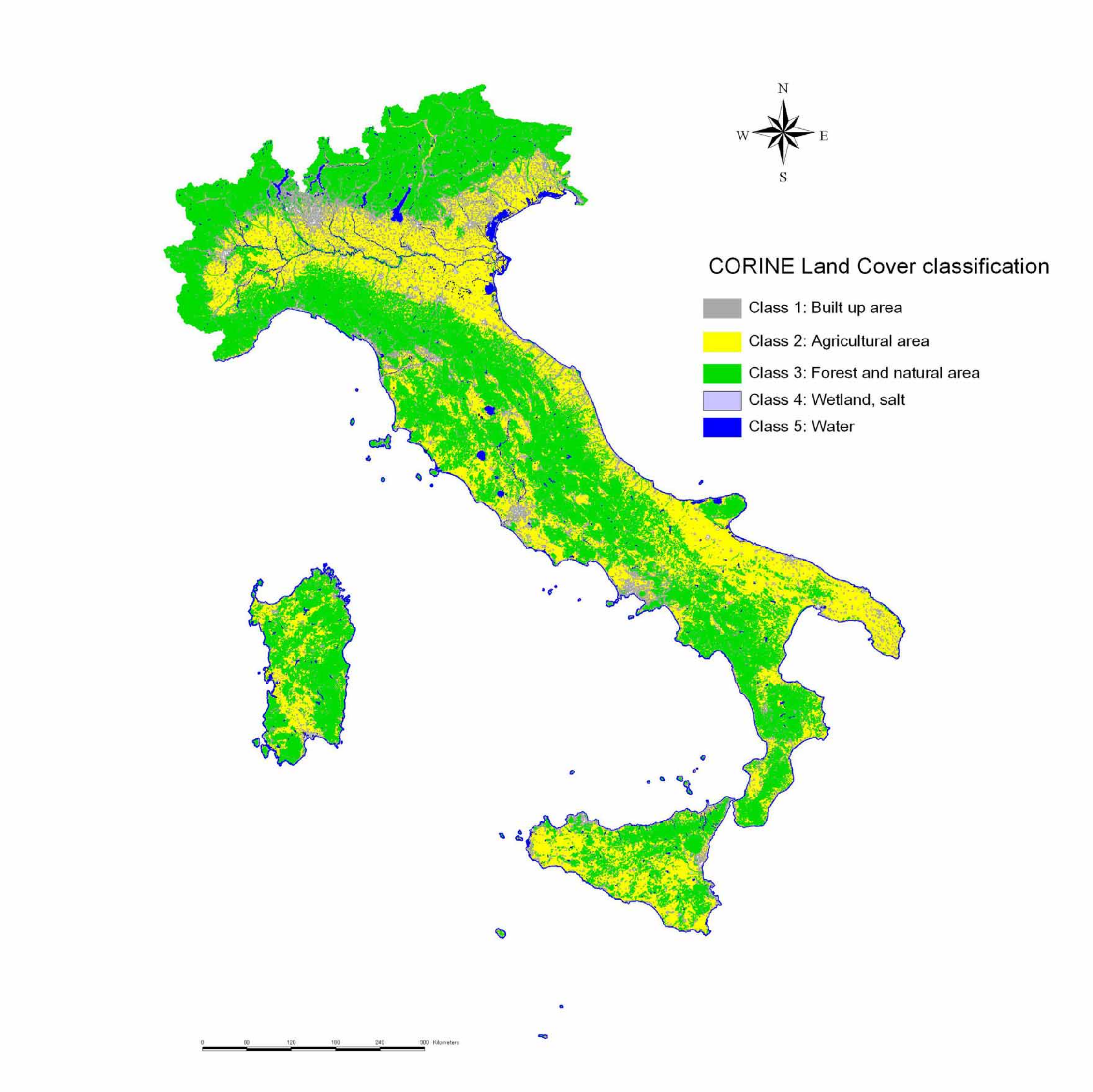
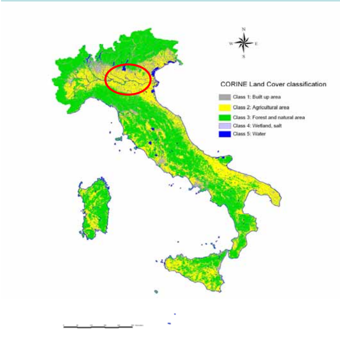
CONSIGLIO PER LA RICERCA
E LA SPERIMENTAZIONE
IN AGRICOLTURA

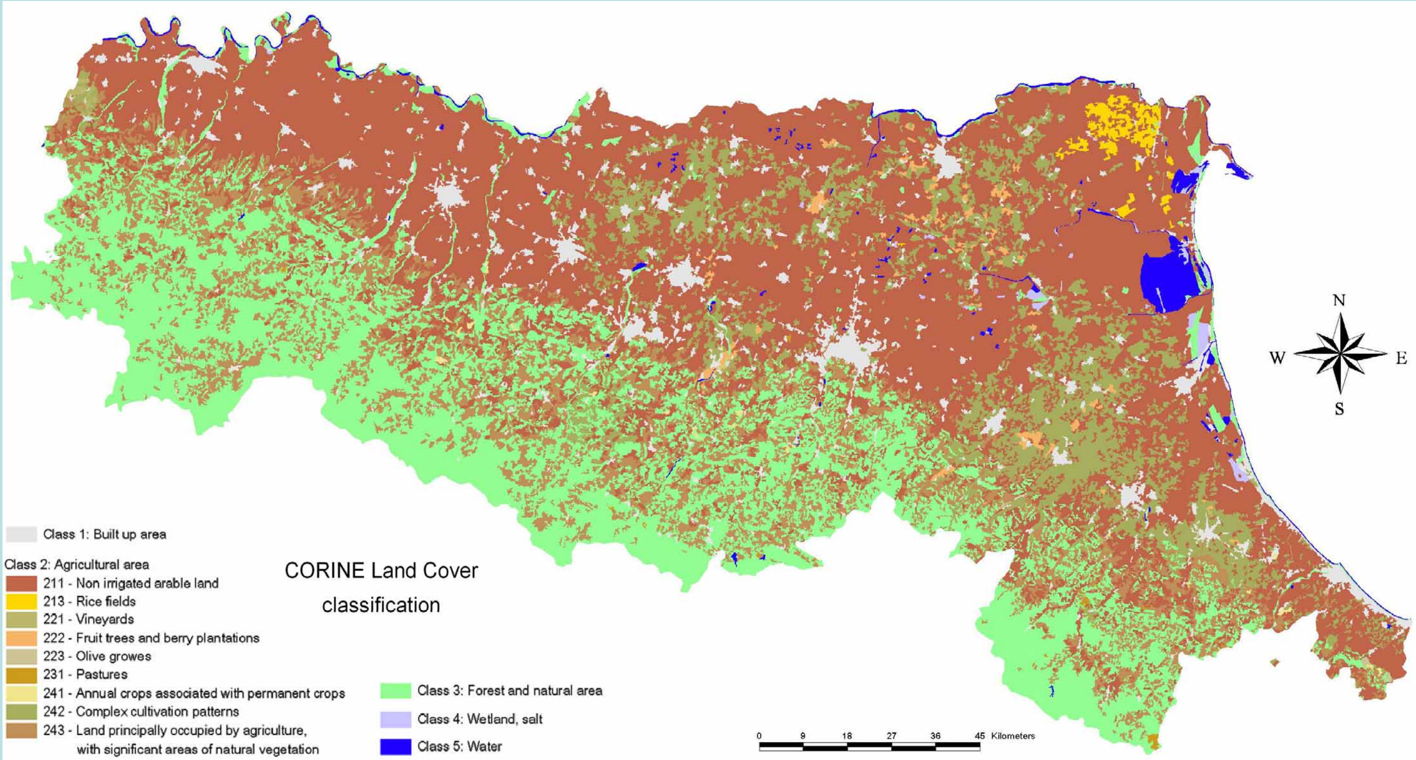
Land use on Italy



Land	%
Built up area	5
Agricultural area	51
Forest	41
Wet land	0.2
Water	3

Agricultural land use in Emilia Romagna



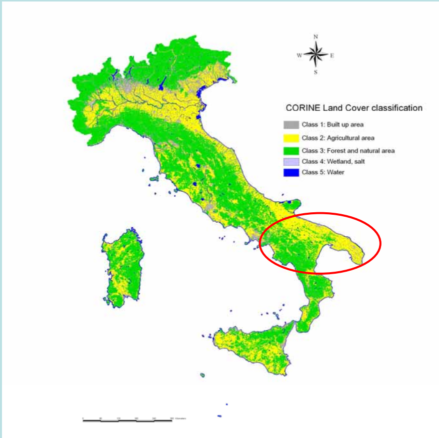


Agricultural area
40%

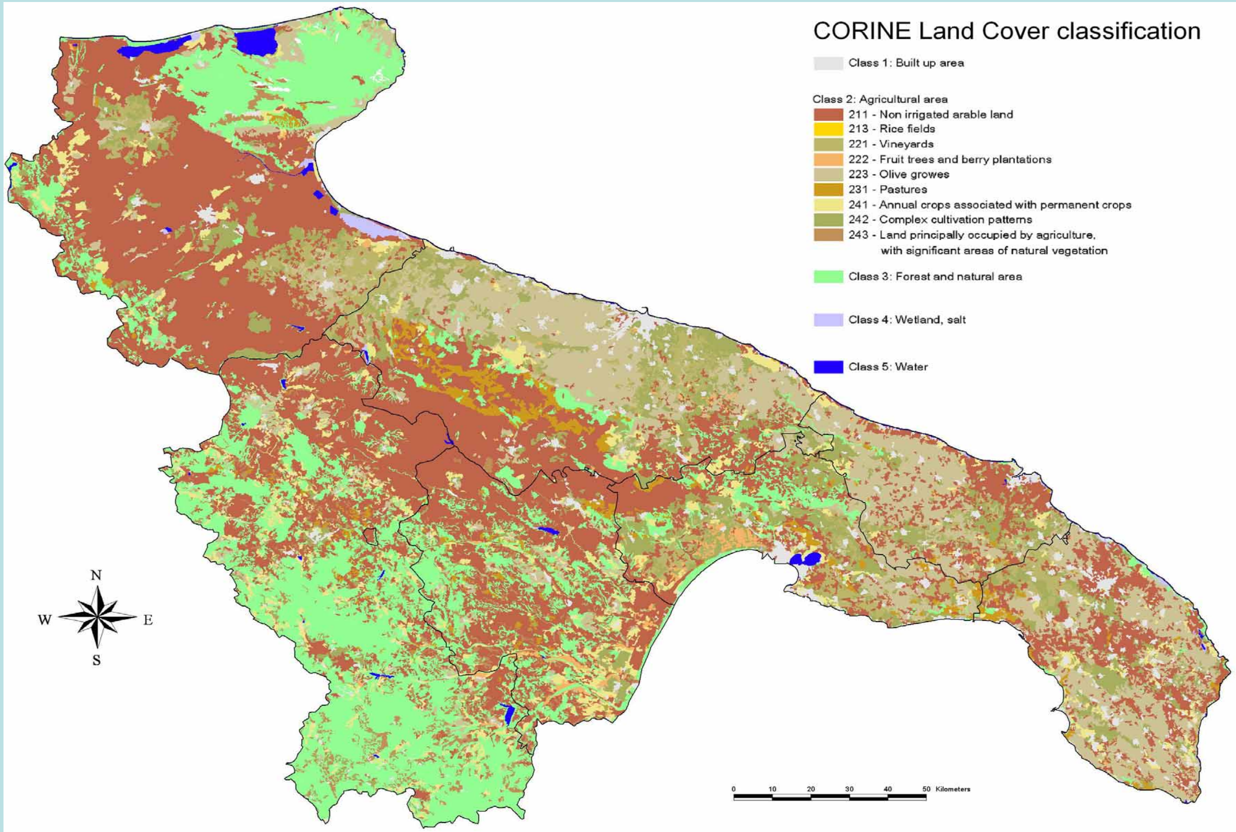
The most important crops:
winter wheat (soft and durum, in the last years), tomato, mais, forage crops (alfalfa)
Tree crops: peach, apple, pear

The most important problems:
Reduction of water resources for irrigation
Irrigation as ordinary practice (corn, alfalfa..)
Early flowering and late frost (for tree crops)
No yield for alfalfa in summer

Agricultural land use in Puglia-Basilicata



Agricultural area 43%



The most important crops:
durum winter wheat, tomato, winter vegetable, water melon, cabbage

Tree crops: vineyard, olive, almond, citrus

The most important problems:
Reduction of water resources for irrigation
Salinization in the costal areas
Increase of irrigation practice
Supplemental irrigation for winter crops
Early flowering and late frost (for tree crops)

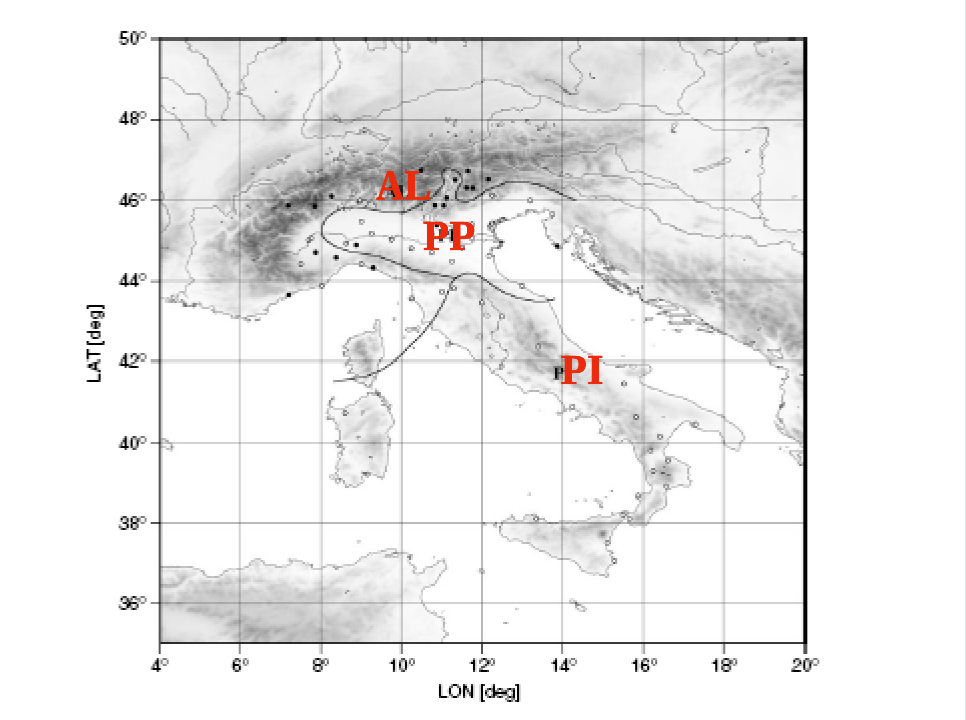
The Temperature variability in Italy

Three Regions on Temperature Basis

Alpine Region: **AL**

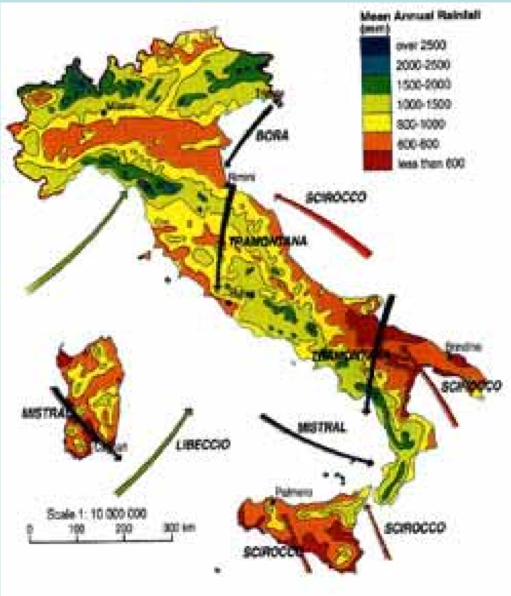
Po Plain: **PP**

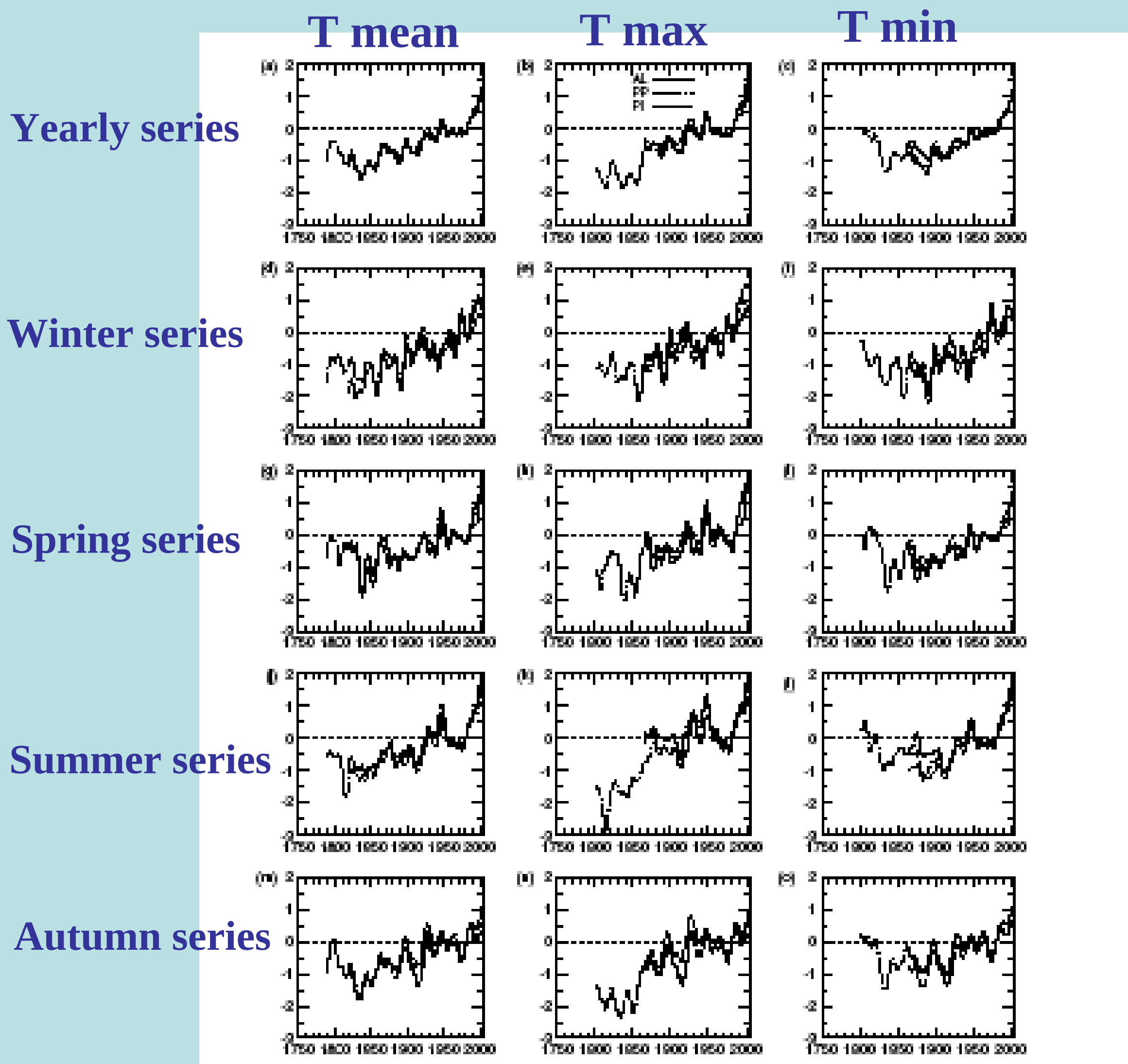
Peninsular Plain: **PI**



From:
TEMPERATURE AND PRECIPITATION VARIABILITY IN ITALY IN THE LAST TWO CENTURIES FROM HOMOGENISED INSTRUMENTAL TIME SERIES
M. BRUNETTI, M.MAUGERI, F. MONTI and T. NANNI
Int. J. Climatol. 26**: 345–381 (2006)**

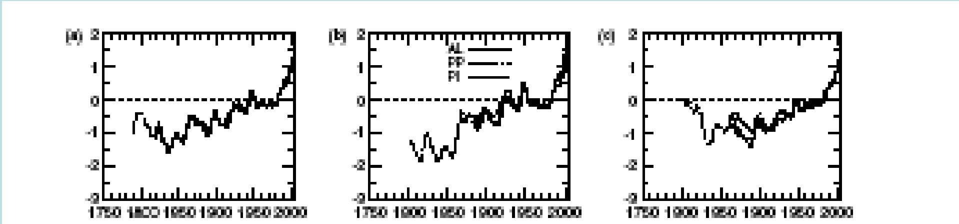
The Temperature Variability in Italy





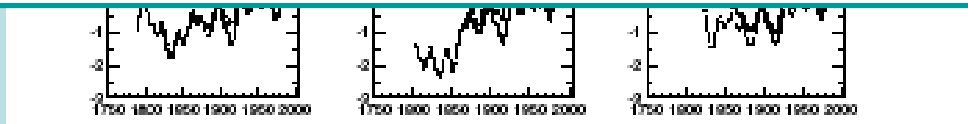
Adapted from Brunetti et al. 2006

The Temperature Variability in Italy



Quite a uniform temperature trend was observed in the different regions, with an increment of 1 K per century all over Italy on a yearly basis.

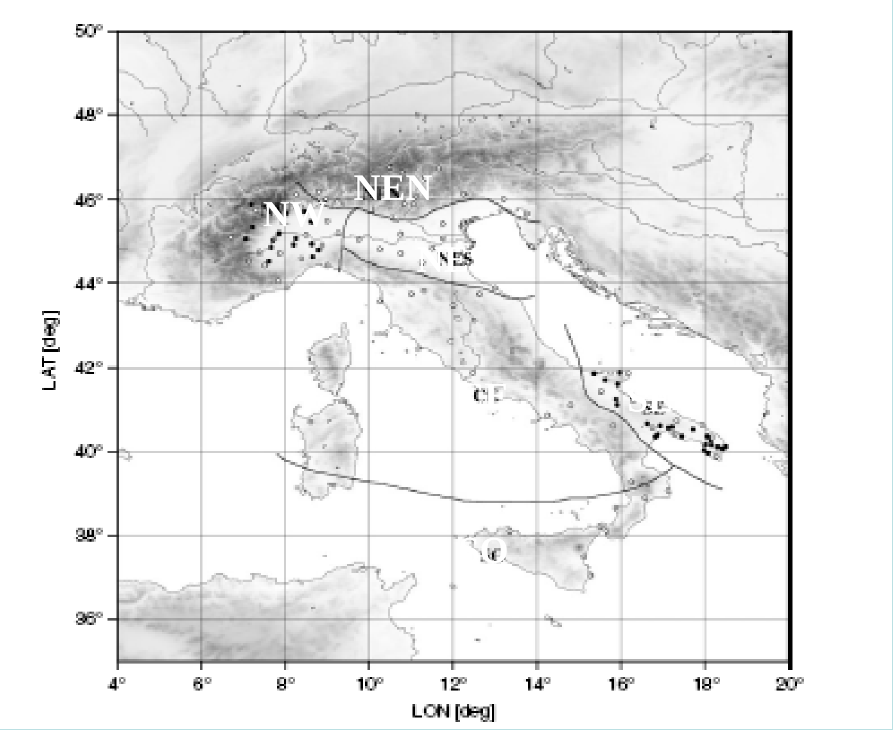
Also on a seasonal basis the situation is quite uniform and no significant differences are evident, either for the different regions or for the different seasons.



Adapted from Brunetti et al. 2006

The Precipitation Variability in Italy

Six Regions on Precipitation Basis



Adapted from Brunetti et al. 2006

The Precipitation Variability in Italy

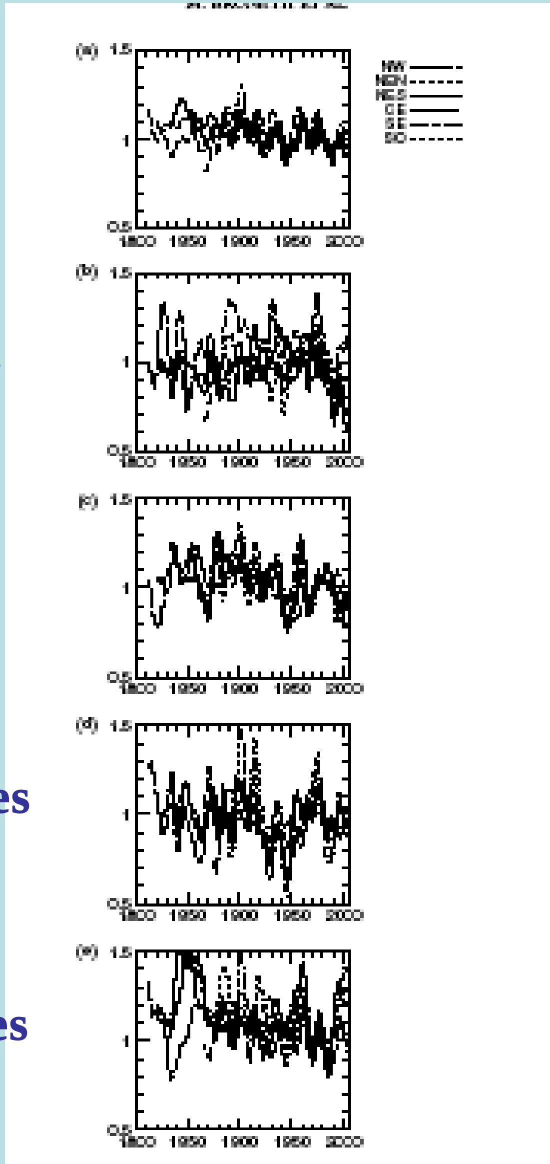
Yearly series

Winter series

Spring series

Summer series

Autumn series



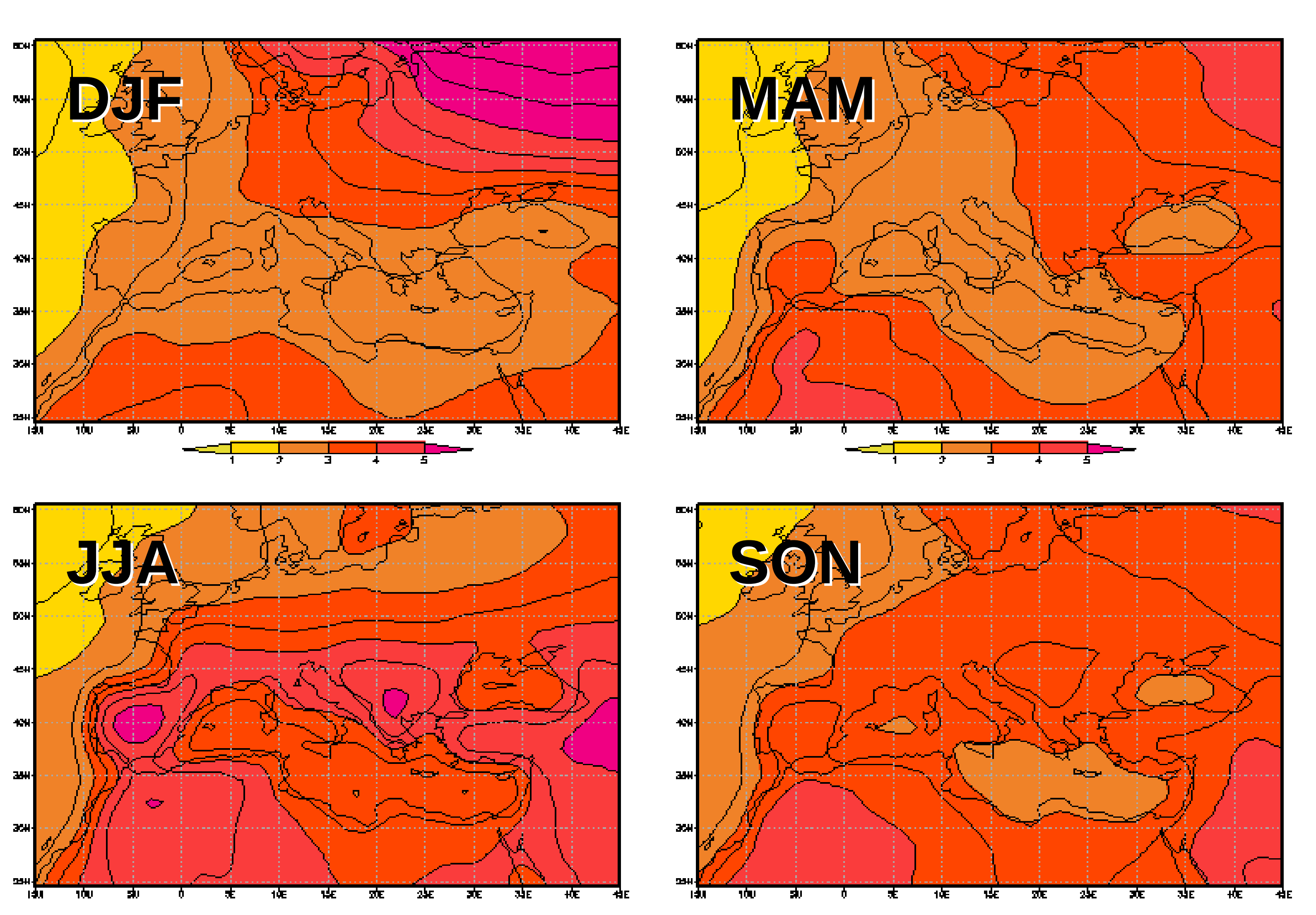
Precipitation trend analysis showed a decreasing tendency. But the decreases are very low and rarely significant. Considering the average all over Italy, there is a 5% decrease per century in the annual precipitation amount, mainly due to the **spring** season (−9% per century)

Adapted from Brunetti et al. 2006

What is changing in this century?

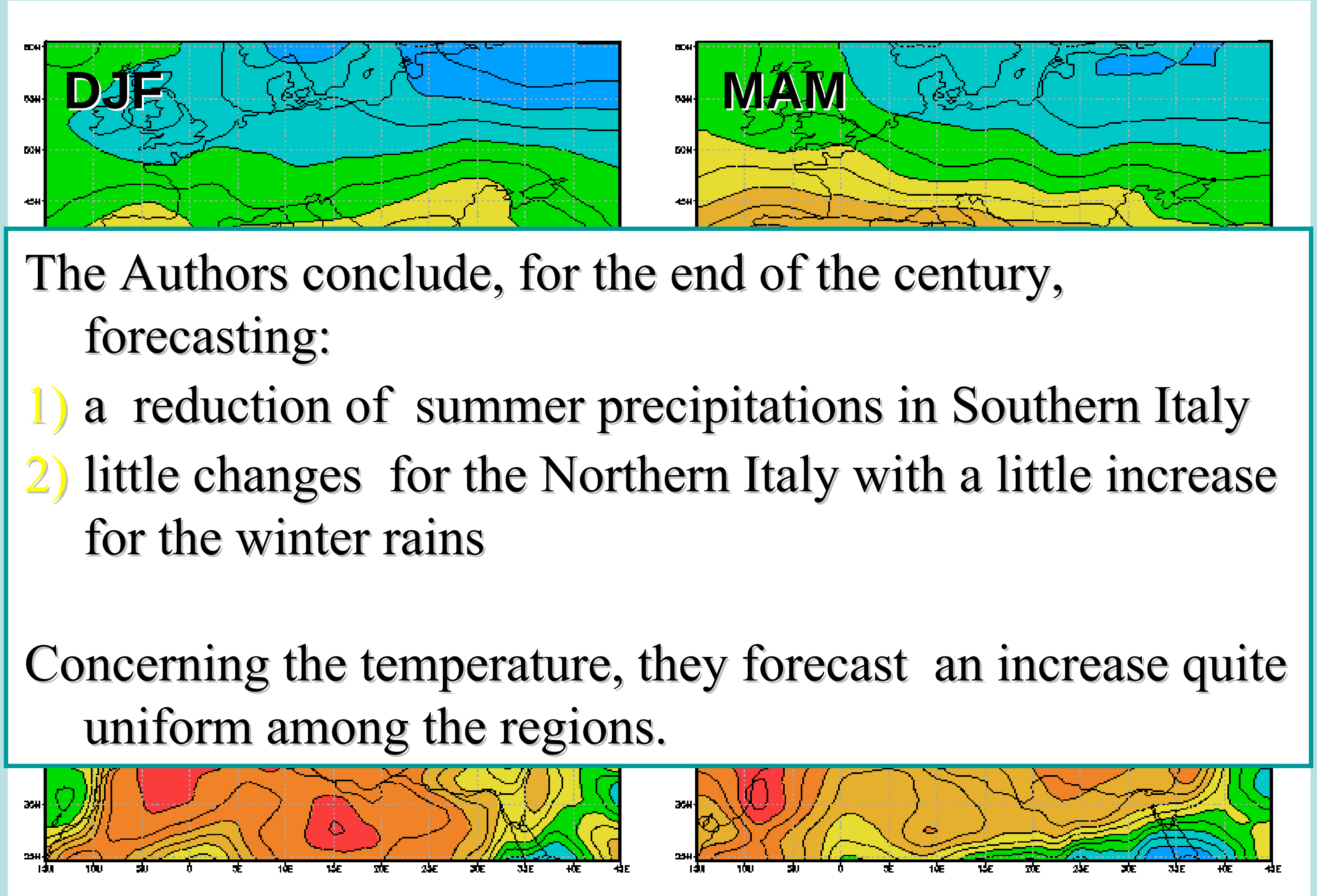
- Increase of global mean temperature: from 2 to 6° C and consequently increase of soil evaporation
- Increase of emission and concentration of CO_2
- About the rainfall:
  - Increase or decreasing annual rainfall.
  - Increase rainfall intensity.
  - Changing of rainfall distribution.

Temperature change (C, 2071-2100 minus 1961-1990), MGME ensemble average, A1B scenario



from Giorgi and Lionello, submitted

Precipitation change (%, 2071-2100 minus 1961-1990), MGME ensemble average, A1B scenario



The Authors conclude, for the end of the century, forecasting:

1) a reduction of summer precipitations in Southern Italy
2) little changes for the Northern Italy with a little increase for the winter rains

Concerning the temperature, they forecast an increase quite uniform among the regions.

from Giorgi and Lionello, submitted

The Climatic data used for the Pilot Assessments

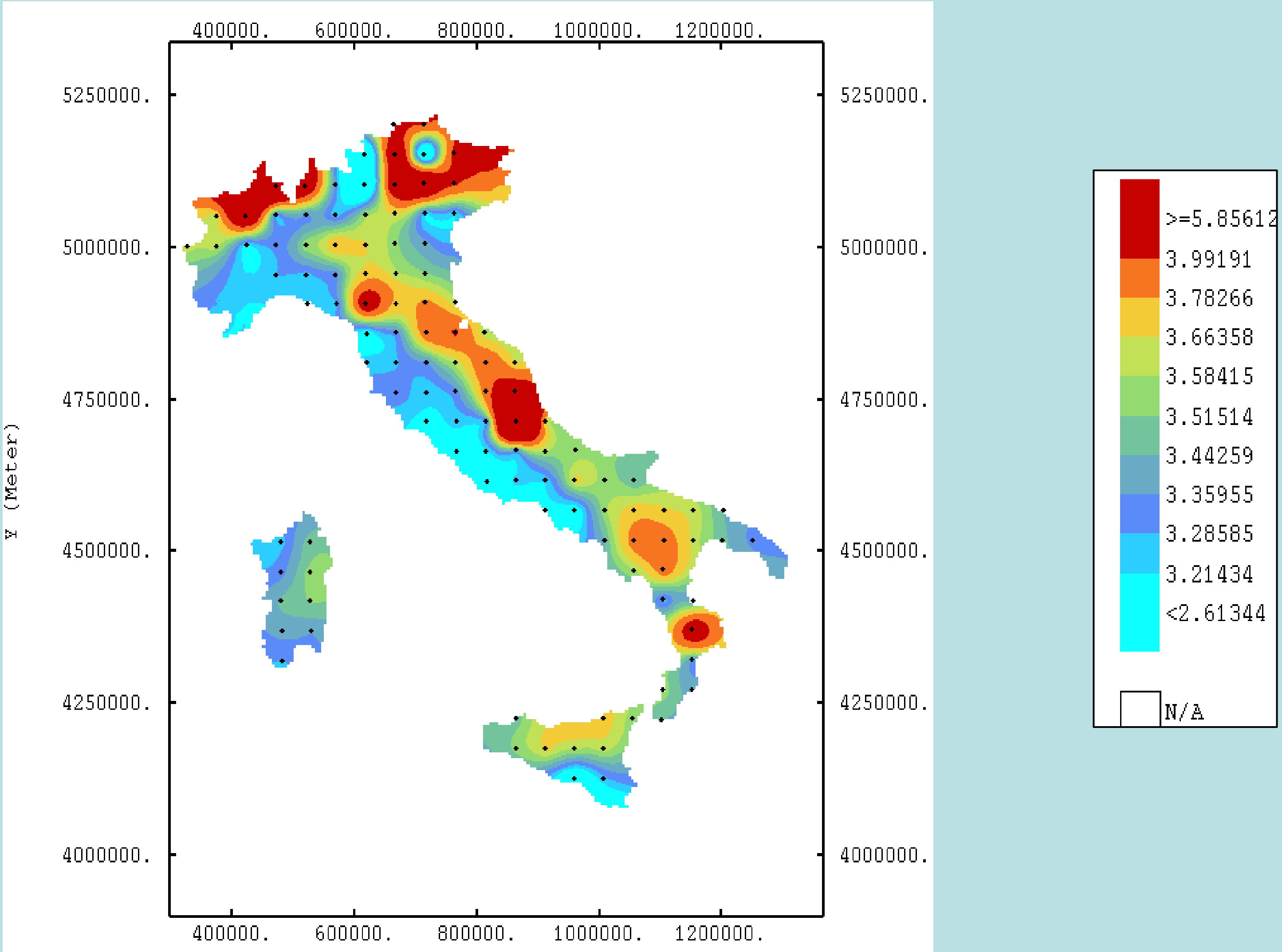
The Regional Circulation Models adopted in this work was **HadRM3P**, developed by the Hadley Centre, UK

HadRM3P has a spatial resolution of 0.44° latitude by 0.44° longitude and is the result of a dynamical downscaling. It takes boundary conditions from a coarser resolution global model and provides a higher spatial resolution of local topography and more realistic simulations of fine-scale weather features. In particular, the outputs from **HadCM3** experiments provide the boundary conditions to drive a high resolution (~120 Km) model of the global atmosphere (HadAM3P). In turn, the outputs from this model provide the boundary conditions to drive the HadRM3P

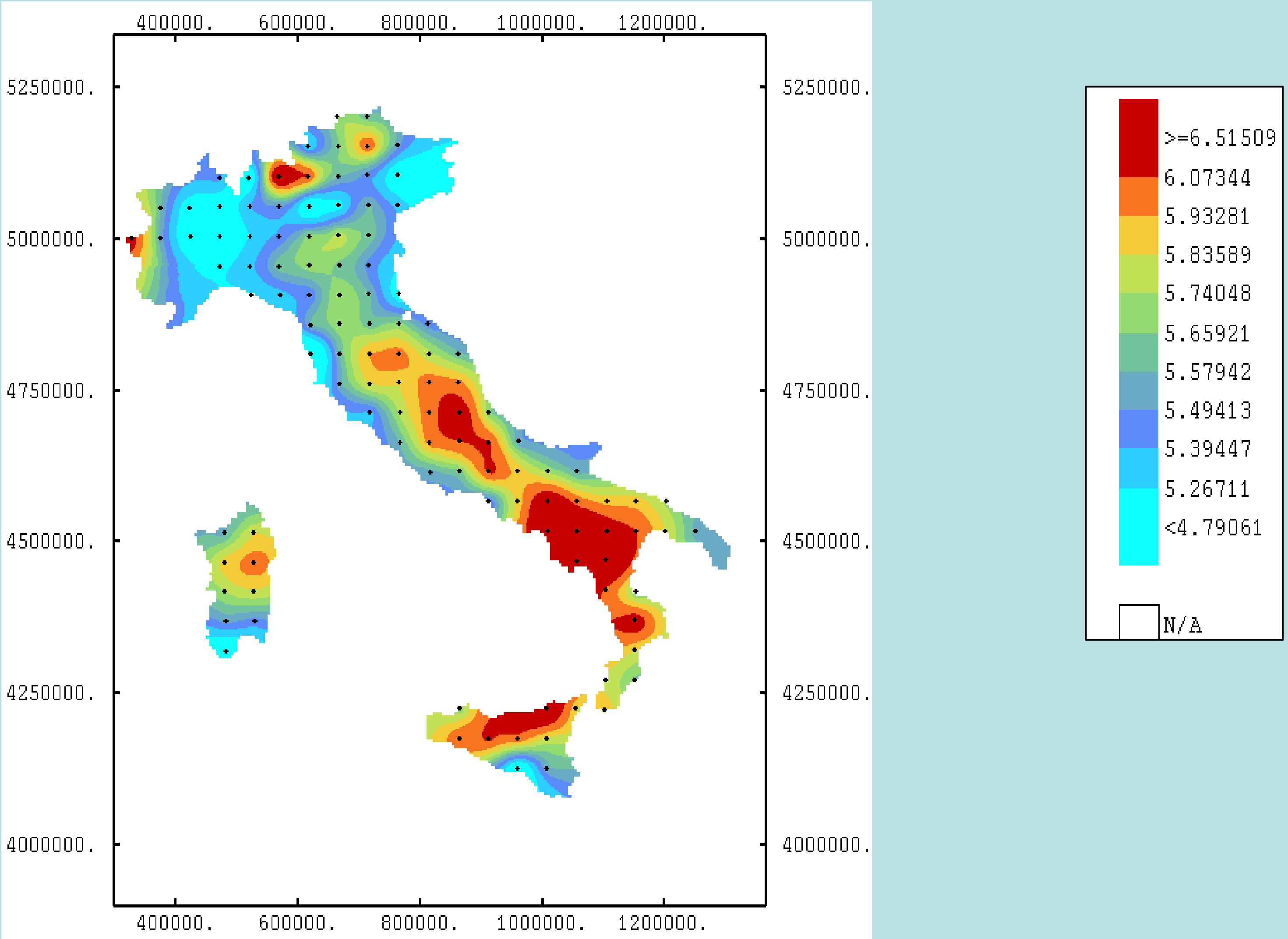
In order to simulate climate change, two emission scenarios (**A2** and **B2**) were selected among those proposed by the Special Report on Emissions Scenarios (IPCC 2000), to have a wide and representative range of changes in temperature patterns

The climatic daily data of the scenarios **A2** and **B2** (from 2071 to 2100) and reference period (**REF**, from 1961 to 1990) were utilized for SWAP and DSSAT applications with unique inizializations

Temperatures (maximum) anomalies of A2 scenario for January-February-March

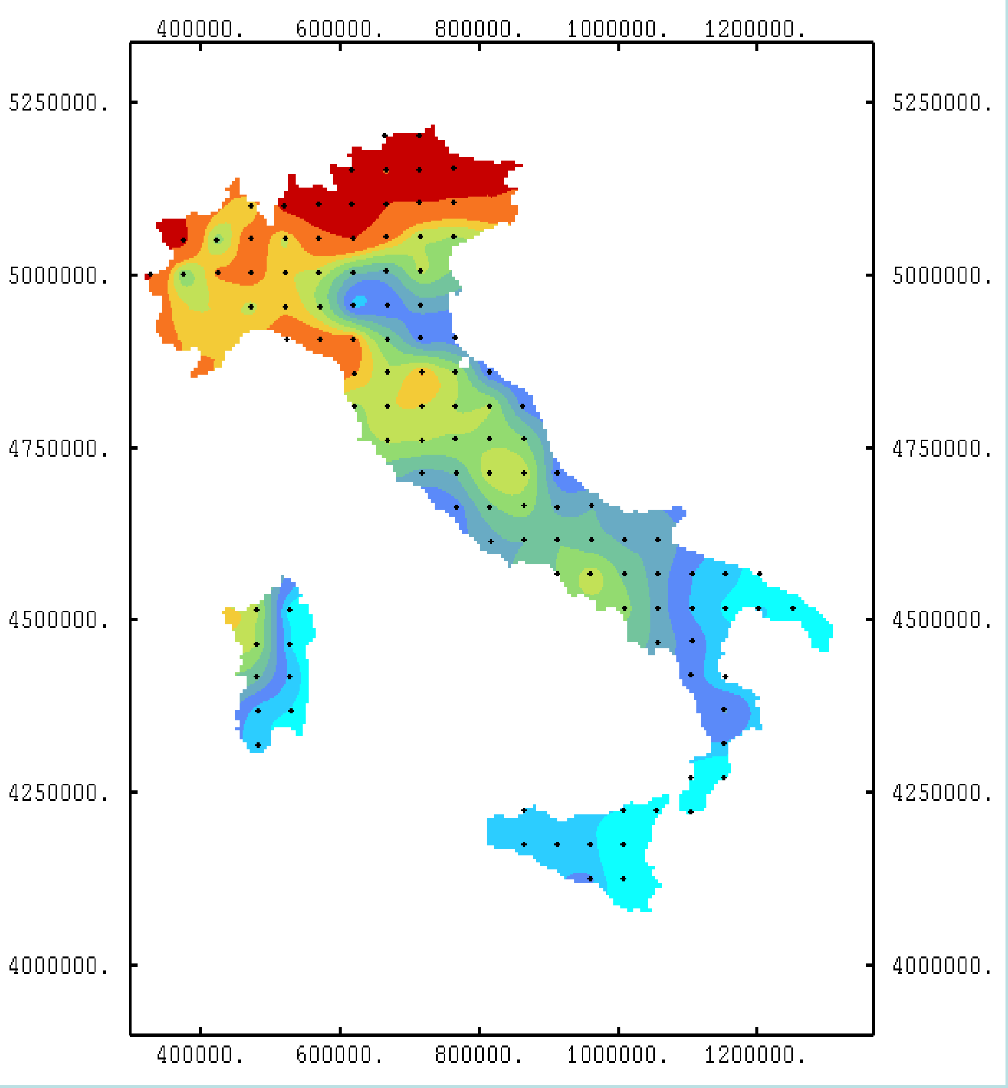


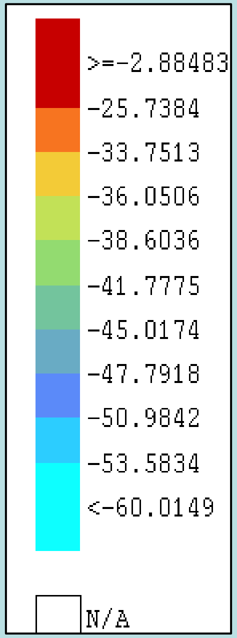
Temperatures (maximum) anomalies of A2 scenario for April-May-June



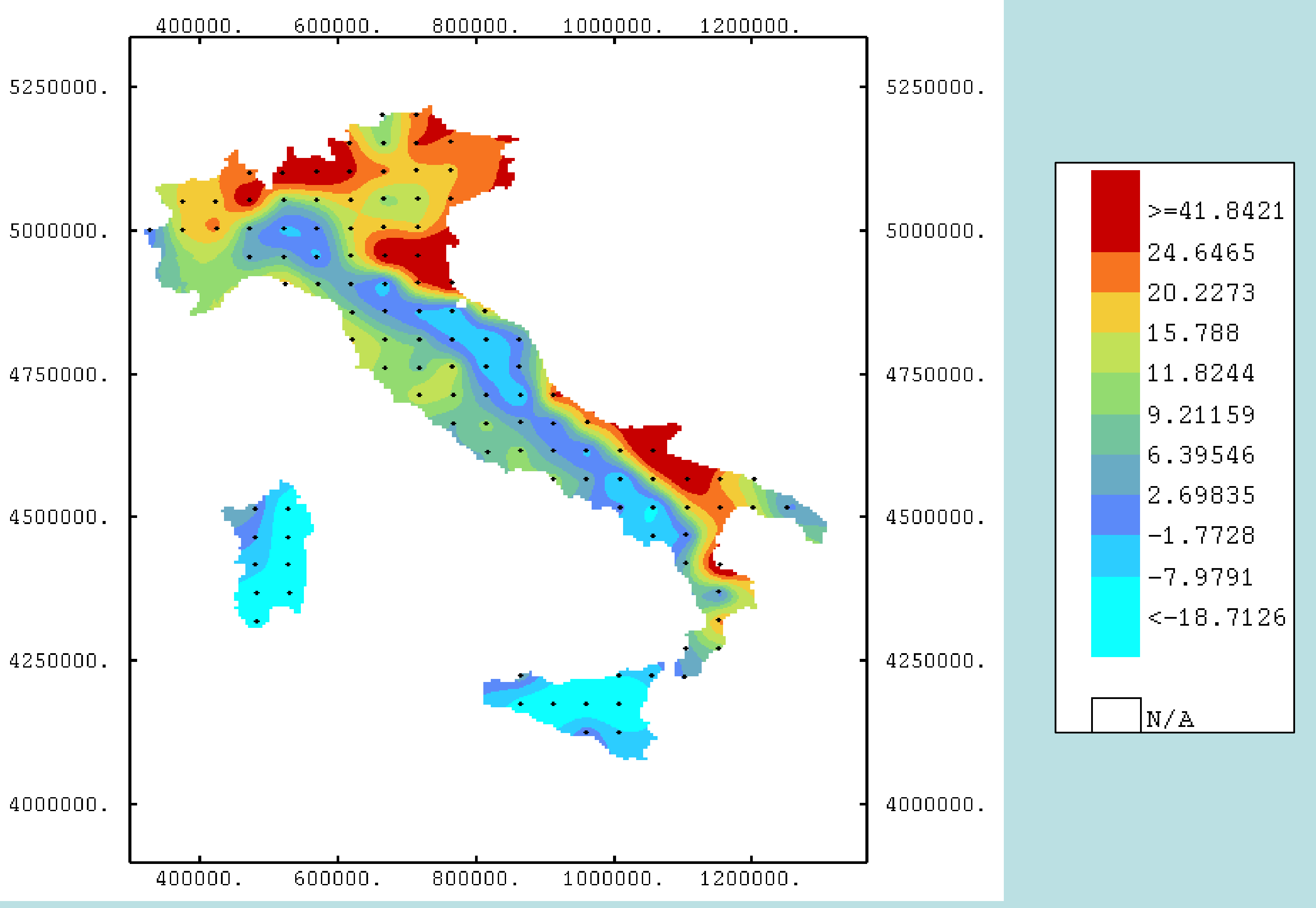
Precipitation anomalies of A2 scenario

for April-May-June





Precipitation anomalies of A2 scenario for October-November December



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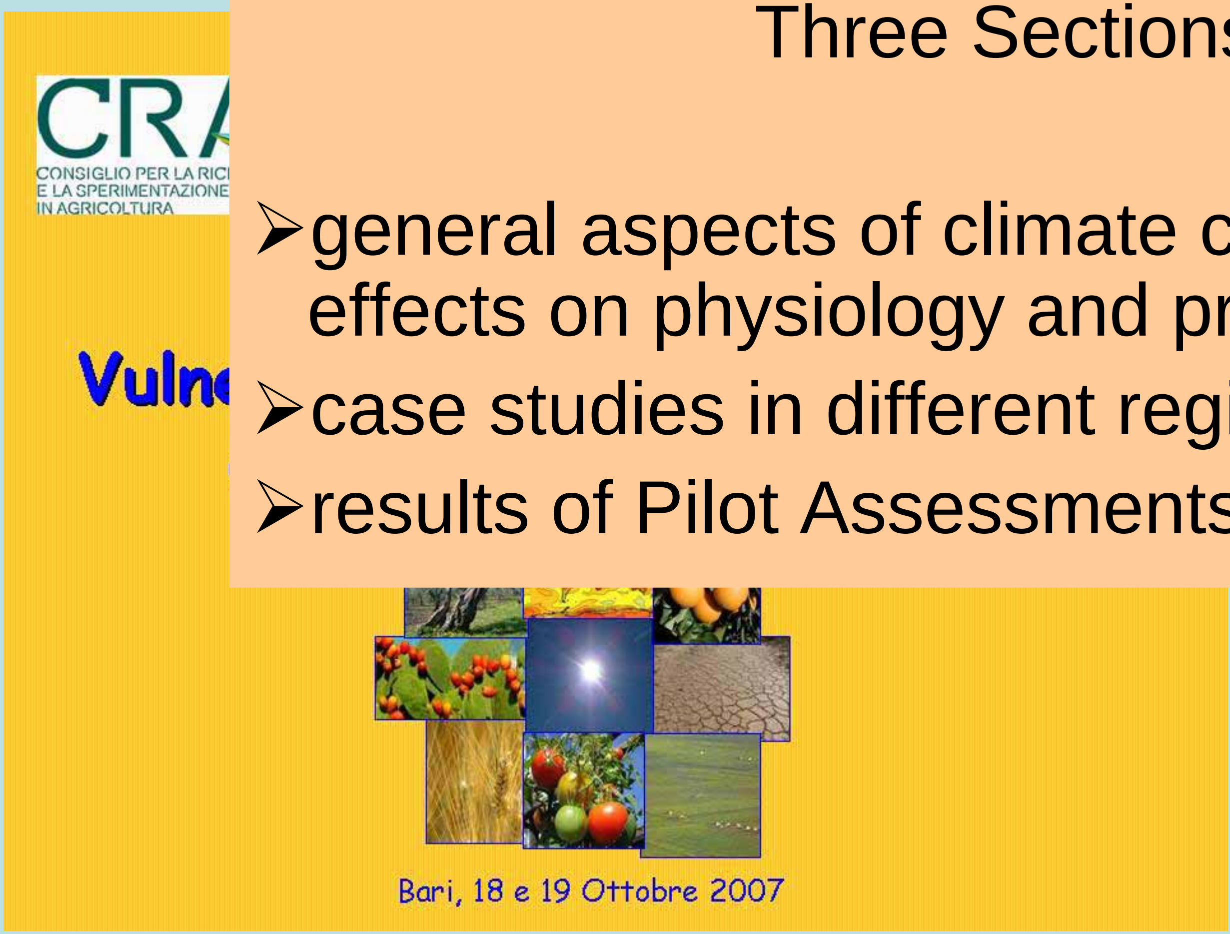
Universities and Applicants for Italy

Marco Bindi	**Università di Firenze** Dipartimento di Scienze Agronomiche e Gestione del Territorio Agroforestale
Maurizio Maugeri	**Università di Milano** Istituto di fisica generale applicata – Climatologia storica
Pietro Santamaria	**Università di Bari** Dipartimento di Scienze delle Produzioni Vegetali
Michele Perniola Stella Lovelli	**Università degli Studi di Basilicata** Dipartimento di Produzione Vegetale
Ricercatori	**CRA-**UR per i sistemi colturali degli ambienti caldoaridi – Bari **CRA-**UR per lo studio dei sistemi colturali – Metaponto (MT)
Emanuele Scalcione	**Agenzia Lucana di Sviluppo e di Innovazione in Agricoltura**
Luigi Trotta	**Regione Puglia** - Assessorato Risorse Agroalimentari - Settore Agricoltura
Paolo Mannini	**CER** Consorzio di bonifica di secondo grado per il Canale Emiliano-Romagnolo
Franco Zinoni	**ARPA** - Agenzia Regionale Prevenzione Ambiente dell'Emilia Romagna Direzione Tecnica
Giovanni Lacertosa	**Metapontum Agrobios**
Antonino Drago	**Regione Sicilia** Servizio Informativo Agrometeorologico Siciliano

The workshop in Bari



Three Sections:

- general aspects of climate change and effects on physiology and productivity
- case studies in different regions
- results of Pilot Assessments

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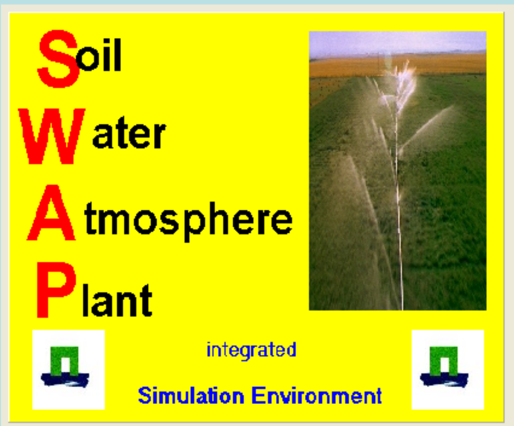
The vulnerability analysis consisted:

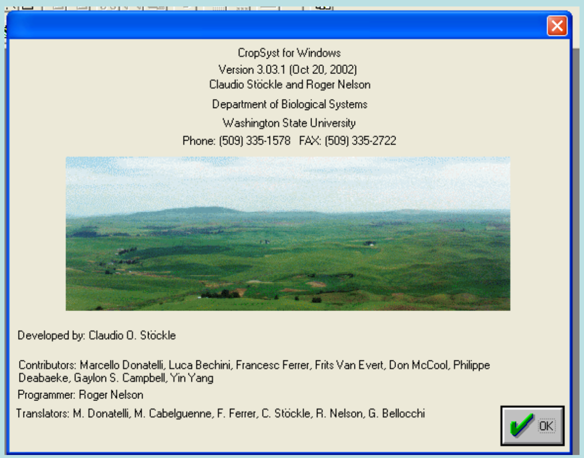
1 Herbaceous crops:

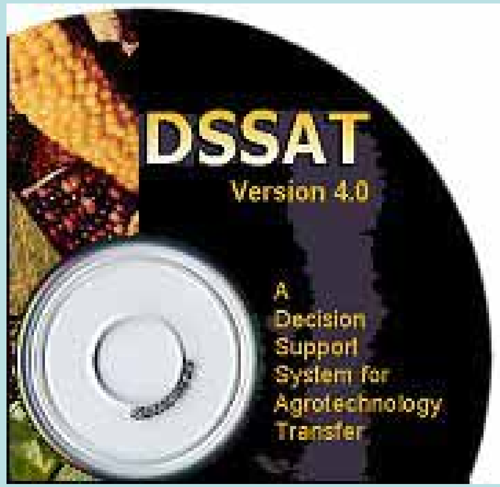
Pilot assessment by using DSSAT, SWAP and Cropsyst for

Tomato

Horticultural species – winter and summer cultivations
Sorghum, Durum/soft wheat







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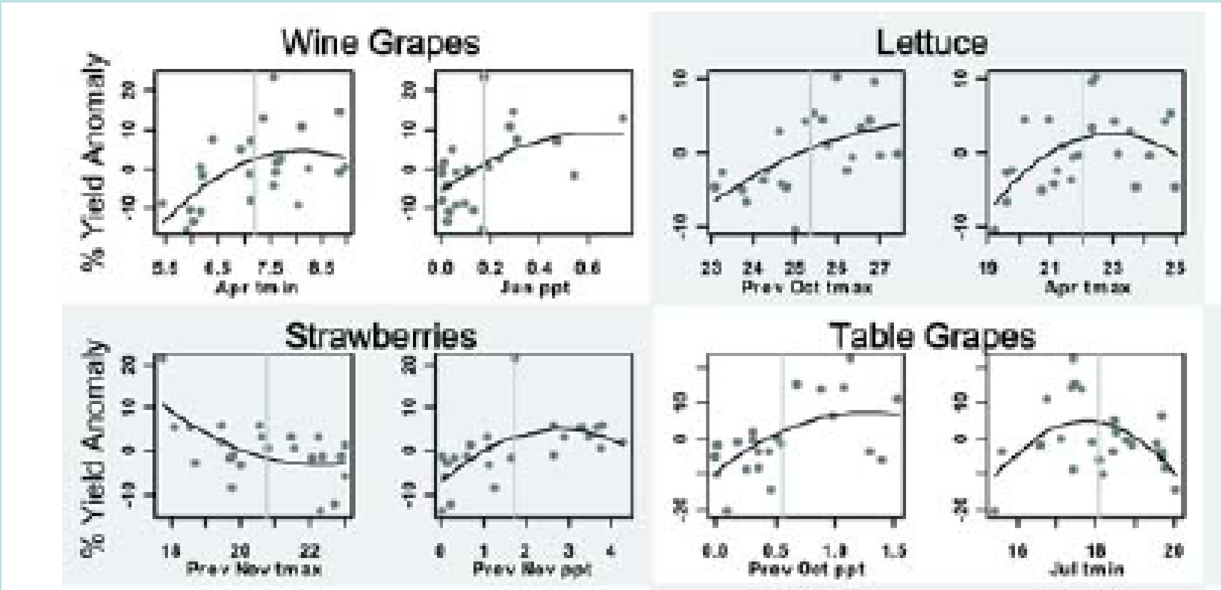
The vulnerability analysis consisted :

2 <u>Tree Crops and durum wheat</u>: Statistical analysis to evaluate the impact of CC on phenological aspects (time of flowering) and productivity using data-set collected in Italy



From: Historical effects of temperature and precipitation on California crop yields D.B. Lobell, K. N. Cahill, C. B. Field, Climatic Change (2007) 81:187–203

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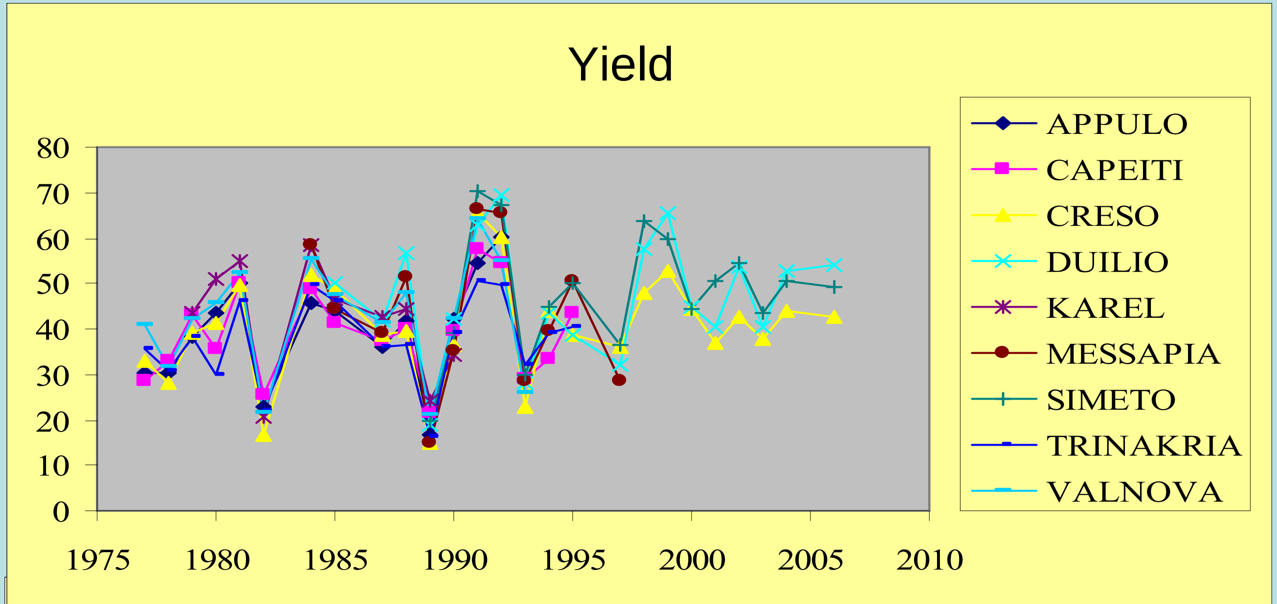
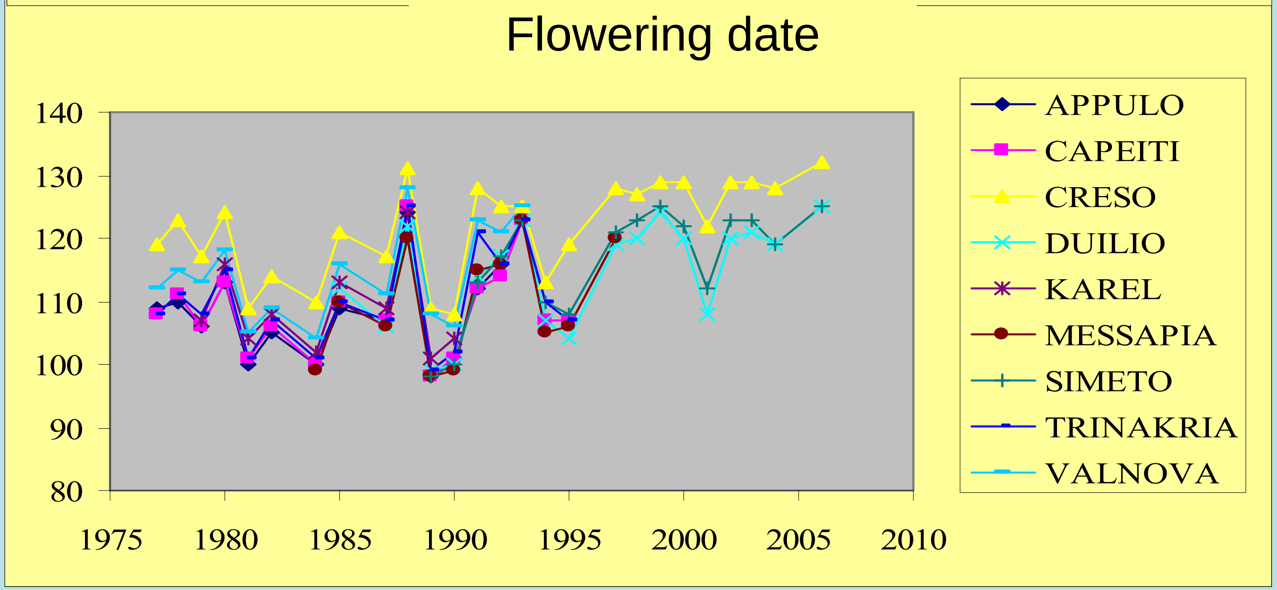
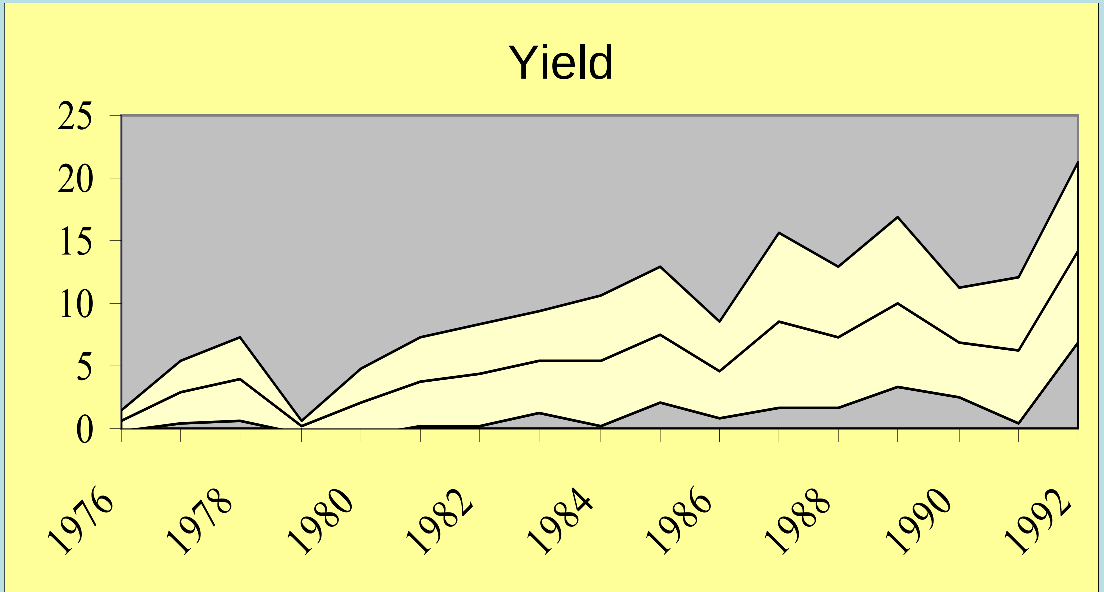
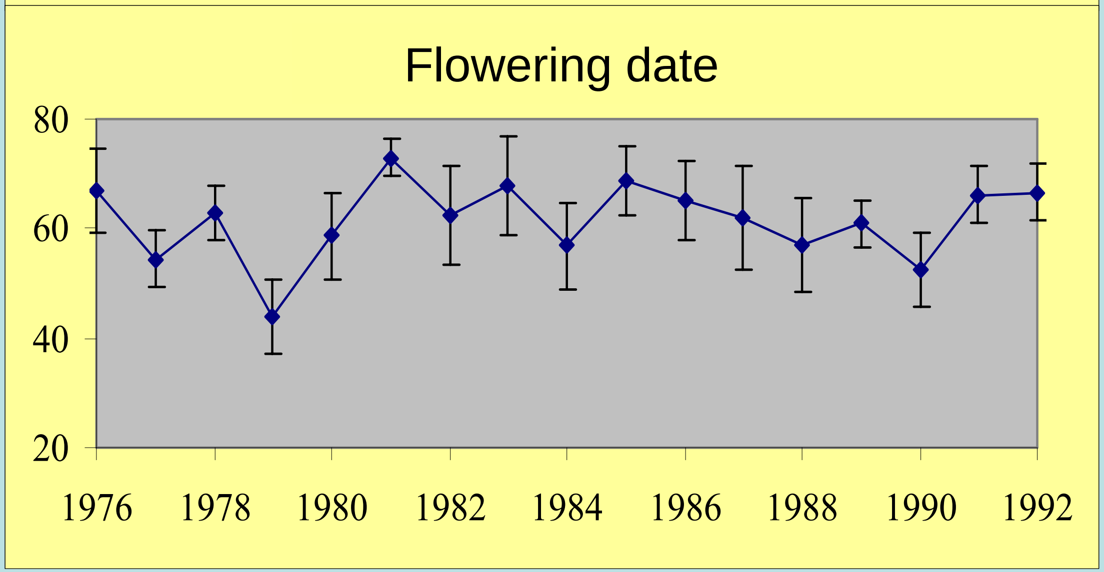
Durum wheat collection





Almond Collection





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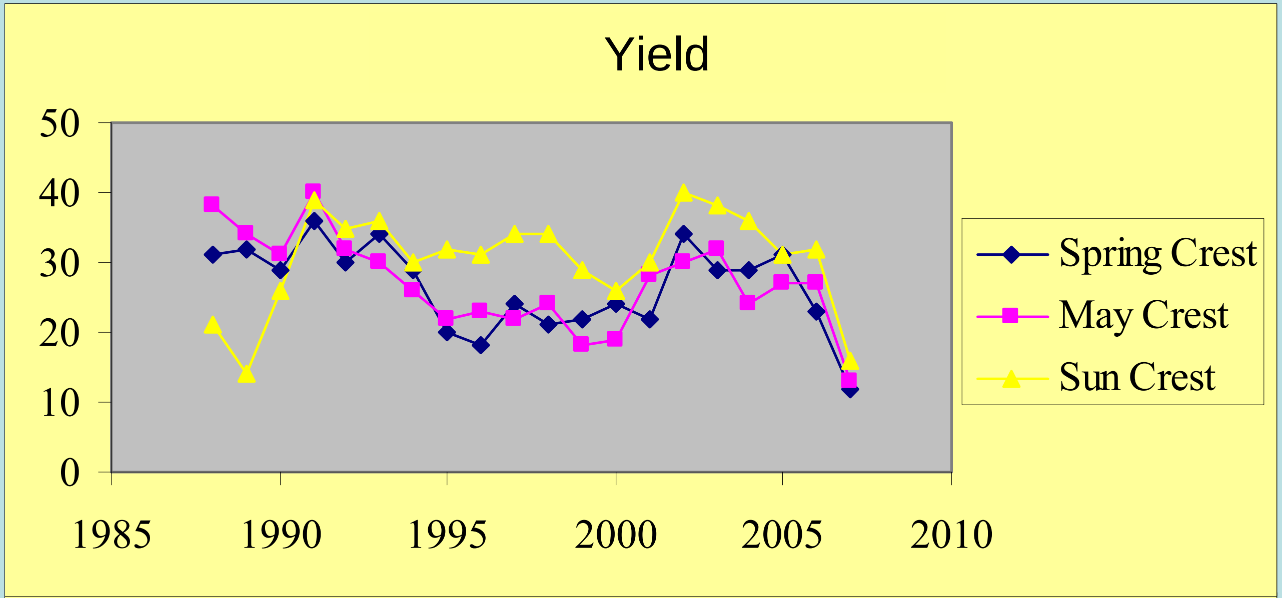
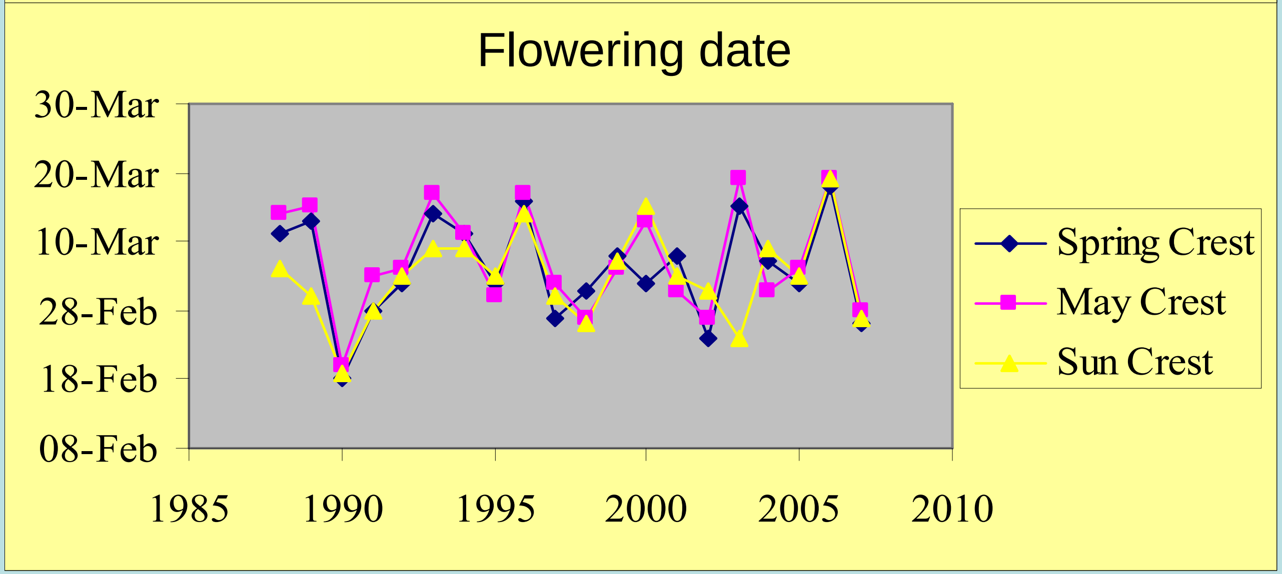
Peach tree Collection





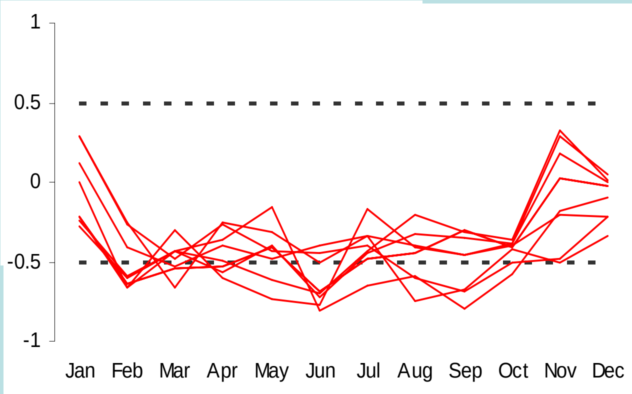
Statistical analysis to evaluate the impact of CC on phenological and productivity aspects of durum wheat

Domenico Vitale, Domenico Ventrella

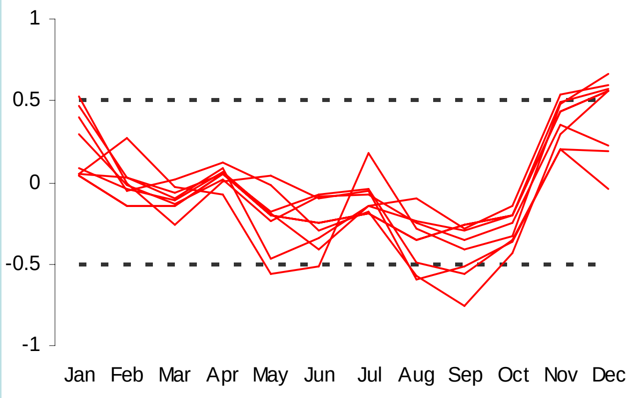
1) Preliminary analysis on meteo data: quality control, Homogenization and gap filling, test to evaluate presence of trend
2) Relationship between flowering time and: (i) cumulated daily temperatures with three different threshold; (ii) precipitation
3) Relationship of flowering time and yield with monthly data of temperature (minimum and maximum) and precipitation

1) Correlation between temperature and precipitation

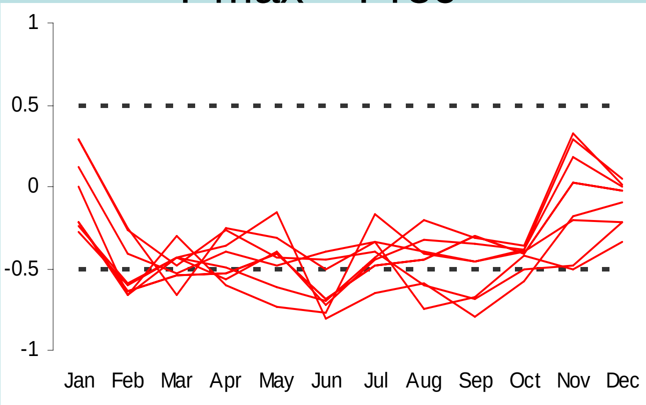
T min – T Max



T min – Prec



T max – Prec



2) Relationship between flowering time and:
(i) cumulated daily temperatures with three different threshold 0-10-15°C;
(ii) precipitation

Flowering Time

Cultivar	R^2
Messapia	0.90
Karel	0.89
Capeiti	0.66
Simeto	0.64
Appulo	0.59
Valnova	0.58
Trinakria	0.57
Creso	0.48
Duilio	0.32

Yield

Cultivar	R^2
Simeto	0.93
Karel	0.89
Trinakria	0.83
Capeiti	0.82
Valnova	0.78
Messapia	0.68
Duilio	0.66
Appulo	0.61
Creso	0.52

Vegetative period=f (+ Cumulated temperatures above 0°C)

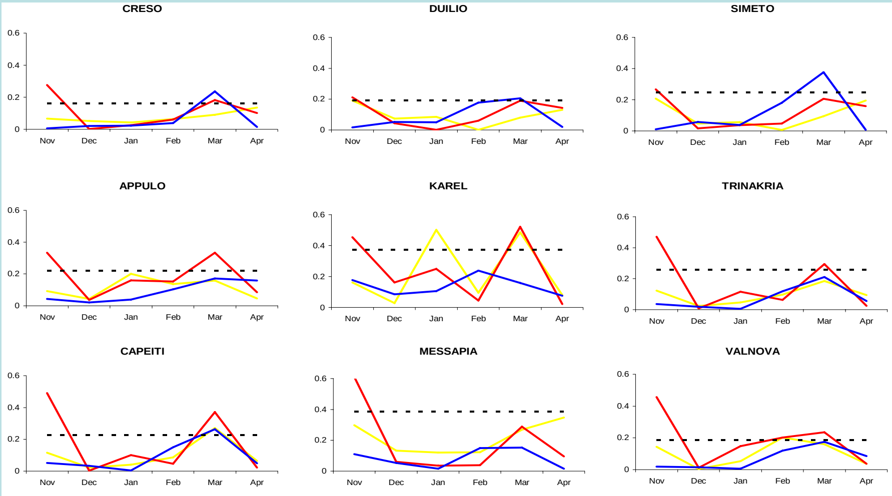
Vegetative period=f (- Cumulated temperatures above 5 and 10°C)

3) Relationship of flowering time and yield with monthly data of temperature (minimum and maximum) and precipitation

3.1 Explorative analysis based on independent regressions between flowering time/yield and monthly means of meteo data: 18 for flowering time (6 months x 3 meteo data); 36 for yield (12 months x 3 meteo data)

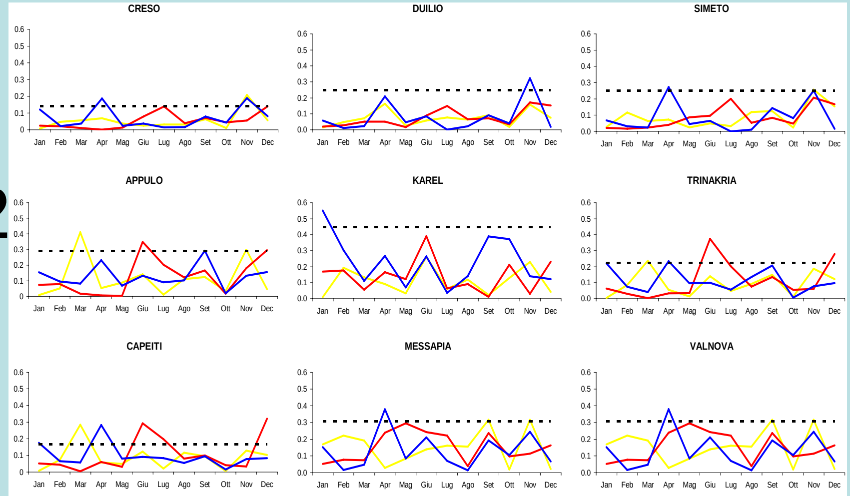
$$Y_t = aX_{J,t} + bX^2_{J,t}$$

Flowering time



R^2

Yield



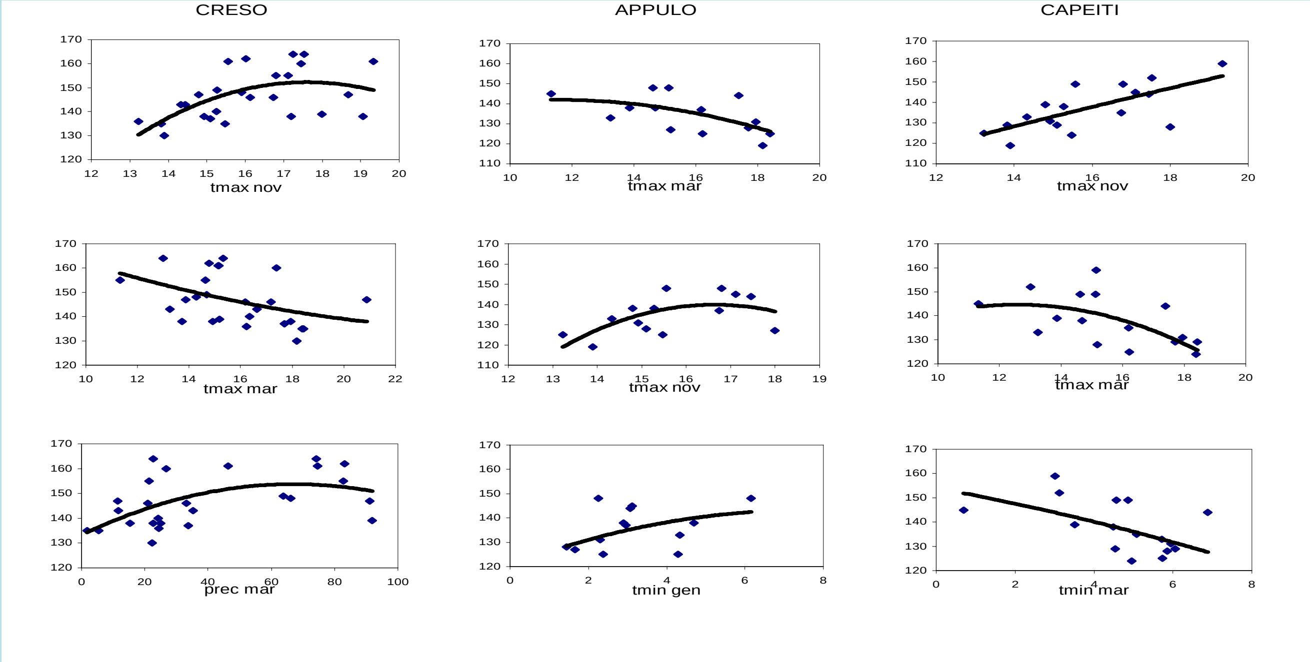
Problem: autocorrelation between meteo data (Tmax vs Tmin, Tmin vs Rainfall...)

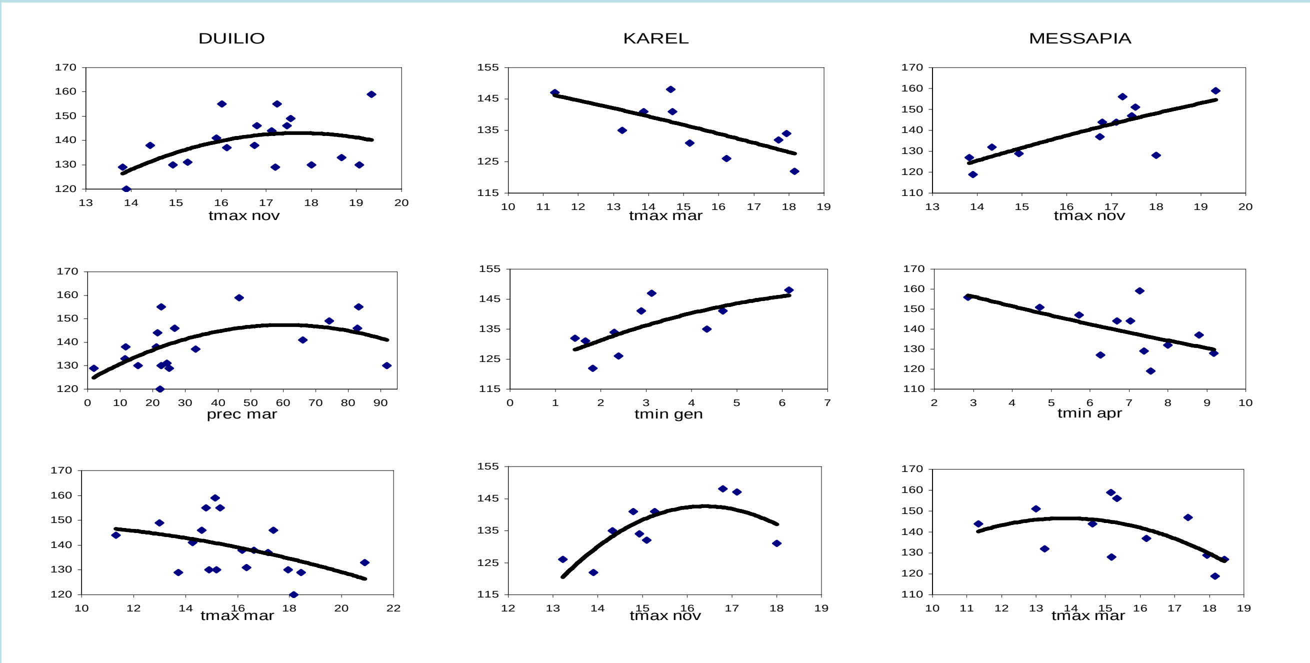
3) Relationship of flowering time and yield with monthly data of temperature (minimum and maximum) and precipitation

3.2 Choice of regression model with the three most significant climatic variables

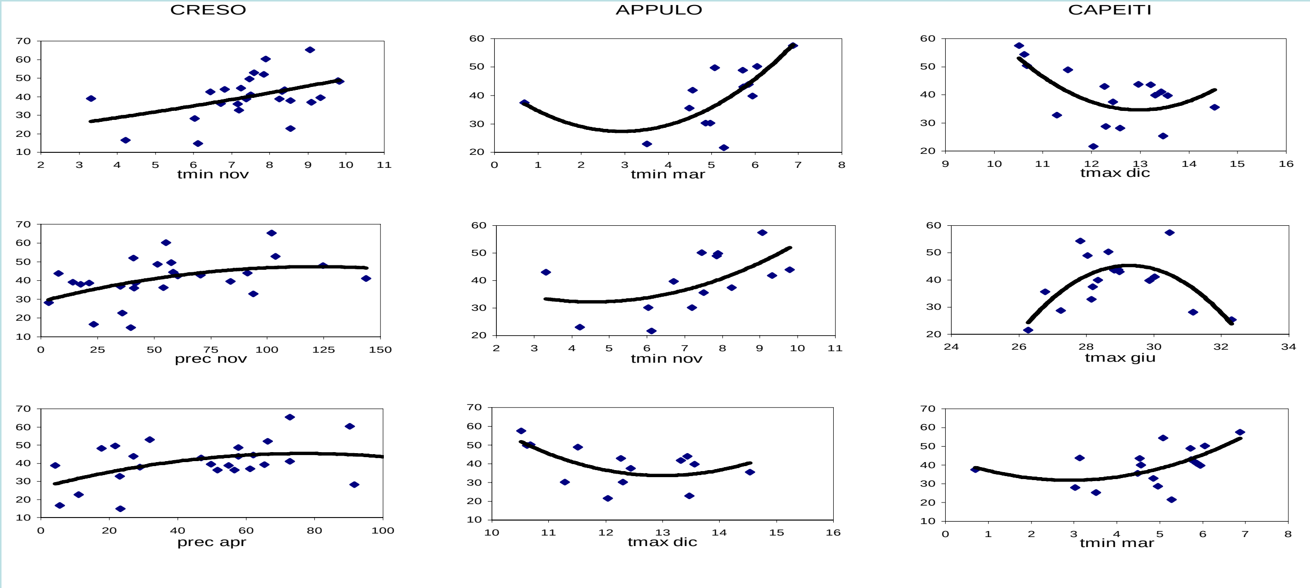
$$Y_t = aX_{1,J,t} + bX^2_{1,J,t} + cX_{2,J,t} + dX^2_{2,J,t} + eX_{3,J,t} + fX^2_{3,J,t}$$

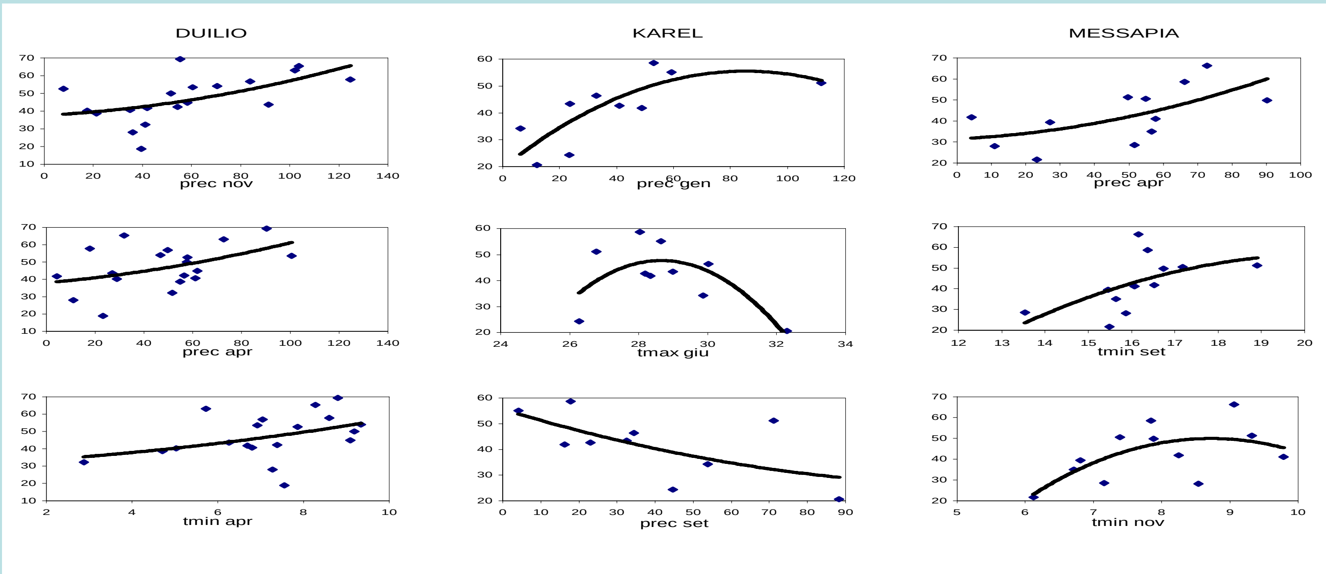
Examples of scatter plots for vegetative period lenght





Examples of scatter plots for Yield





3) Relationship of flowering time and yield with monthly data of temperature (minimum and maximum) and precipitation:

Results

Vegetative period lenght	Maximum temperature of November (+) Maximum Temperature of March (-) Rainfall in March (for *Creso, Duilio and Simeto*)
Yield	Minimum Temperature and Precipitation in November Precipitation in April Minimum Temperature in March

Case studies in Basilicata: winter scarola (lettuce), grain sorghum and water melon

Domenico Ventrella, Luisa Giglio

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IN AGRICOLTURA

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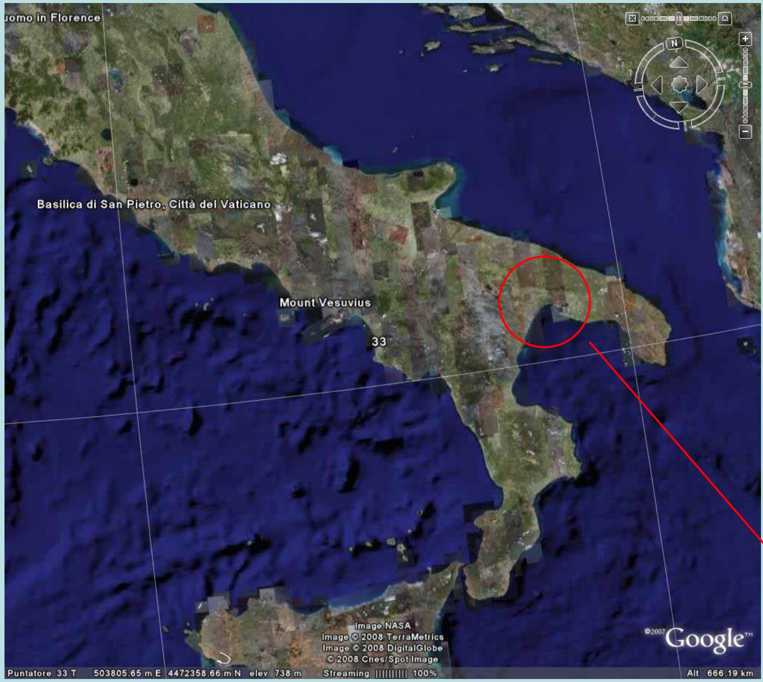
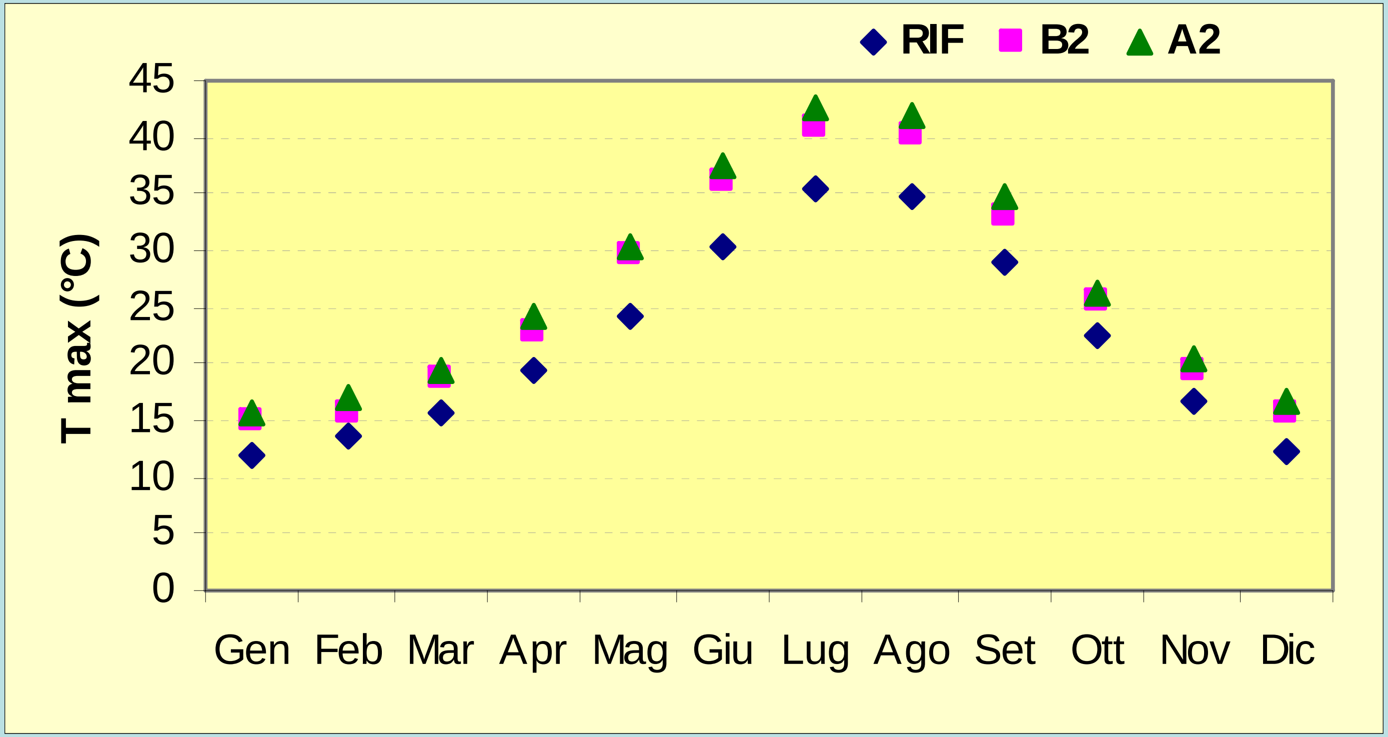
Research Unit for cropping systems in dry environments (CRA-SCA) Bari, Italy

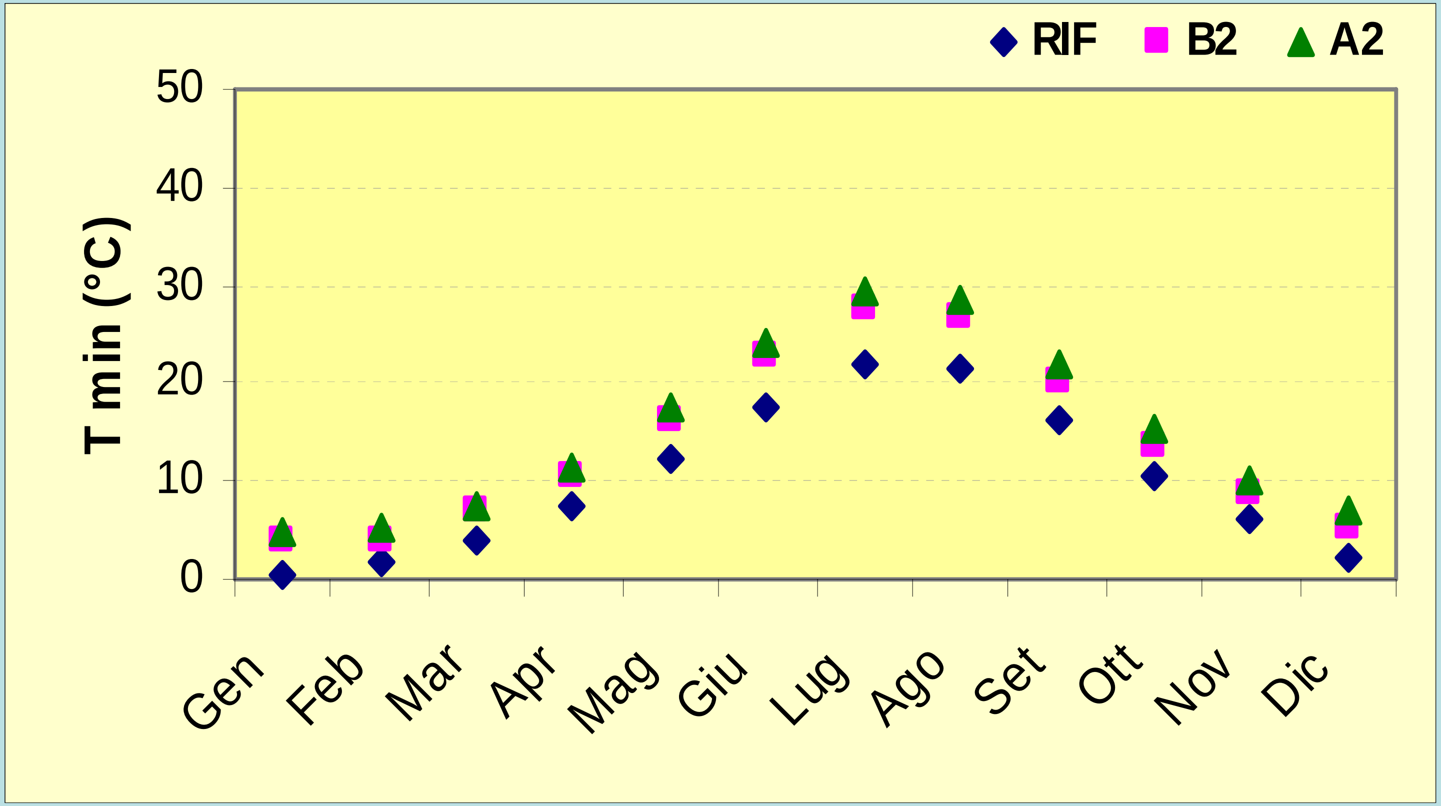
The area of reference:



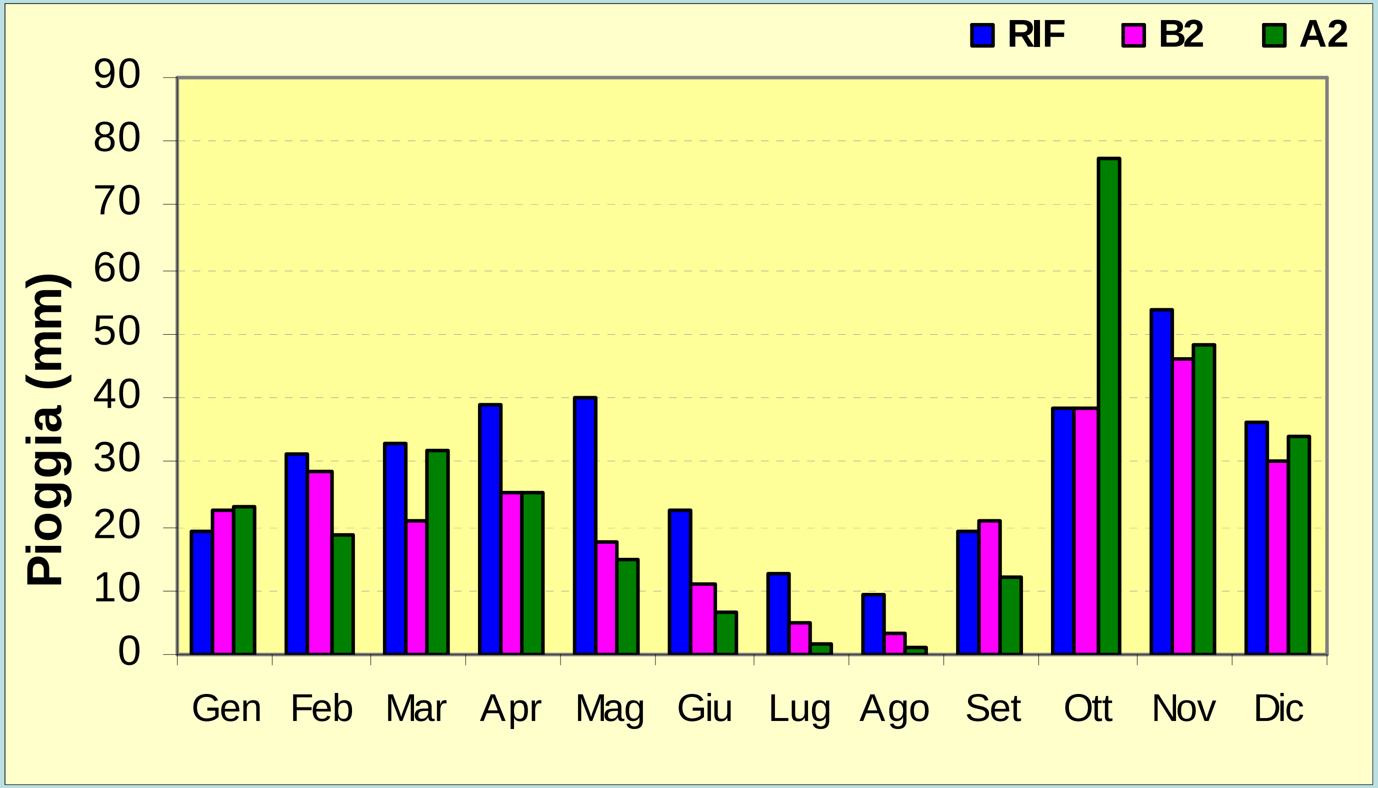
The Maximum Temperature



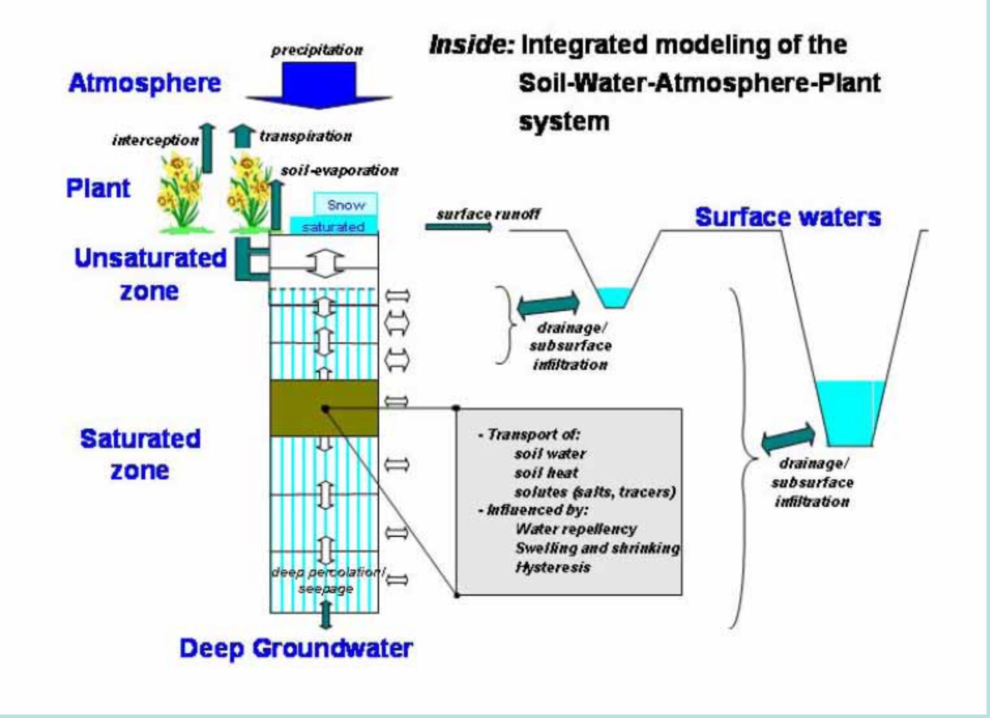
The Minimum Temperature



The Precipitations



SWAP (Soil-Water-Atmosphere-Plant)

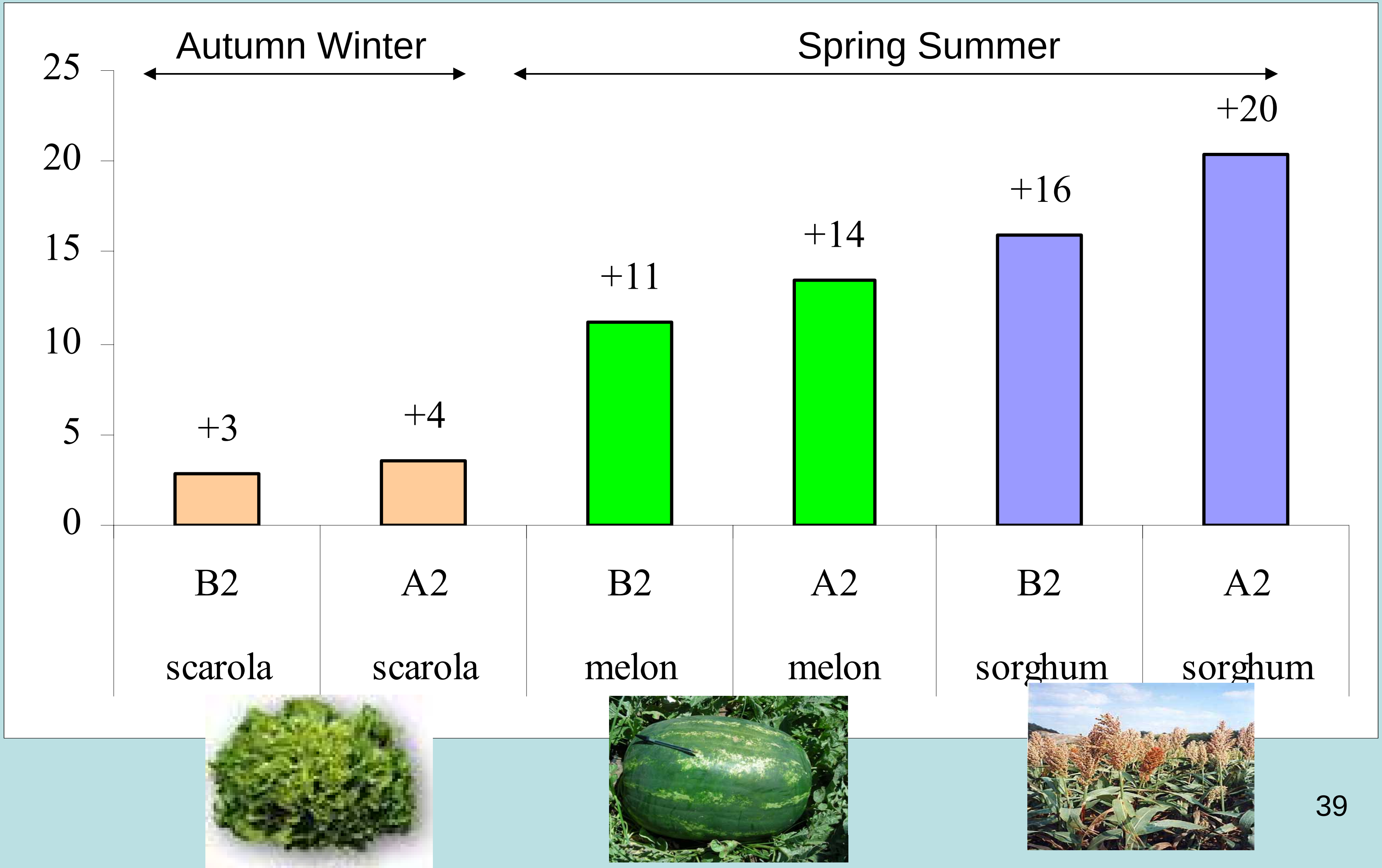


A physical based model that simulates water and solute in saturated an unsaturated soils

The model is particularly useful for field scale

The daily evapotranspiration = the evapotranspirative demand of the atmosphere

$$\Delta_{ETp} = 100 \frac{ETp_{future} - ETp_{past}}{ETp_{past}}$$



Detailed approach (WOFOST) to simulate the sorghum growth

Measured parameters		Calibrated parameters	
TSUMEA	Temperature sum from emergence to anthesis	*SPAN*	Life span of leaves under optimum condition
TSUMAM			use efficiency single
RGRLAI			taneous gross ilation rate at light tion
SLATB			ve maintenance ation of leaves, storage s, roots and stems
TDWI			ency of conversion of ilates into leaves, storage organs, roots and stems
CH	Crop height	*RDC*	Maximum rooting depth of crop
FRTB, FLTB, FSTB, FOTB	Partitioning factors of dry matter into root, leaves, stems and storage organs.	r_c	Minimum canopy resistance

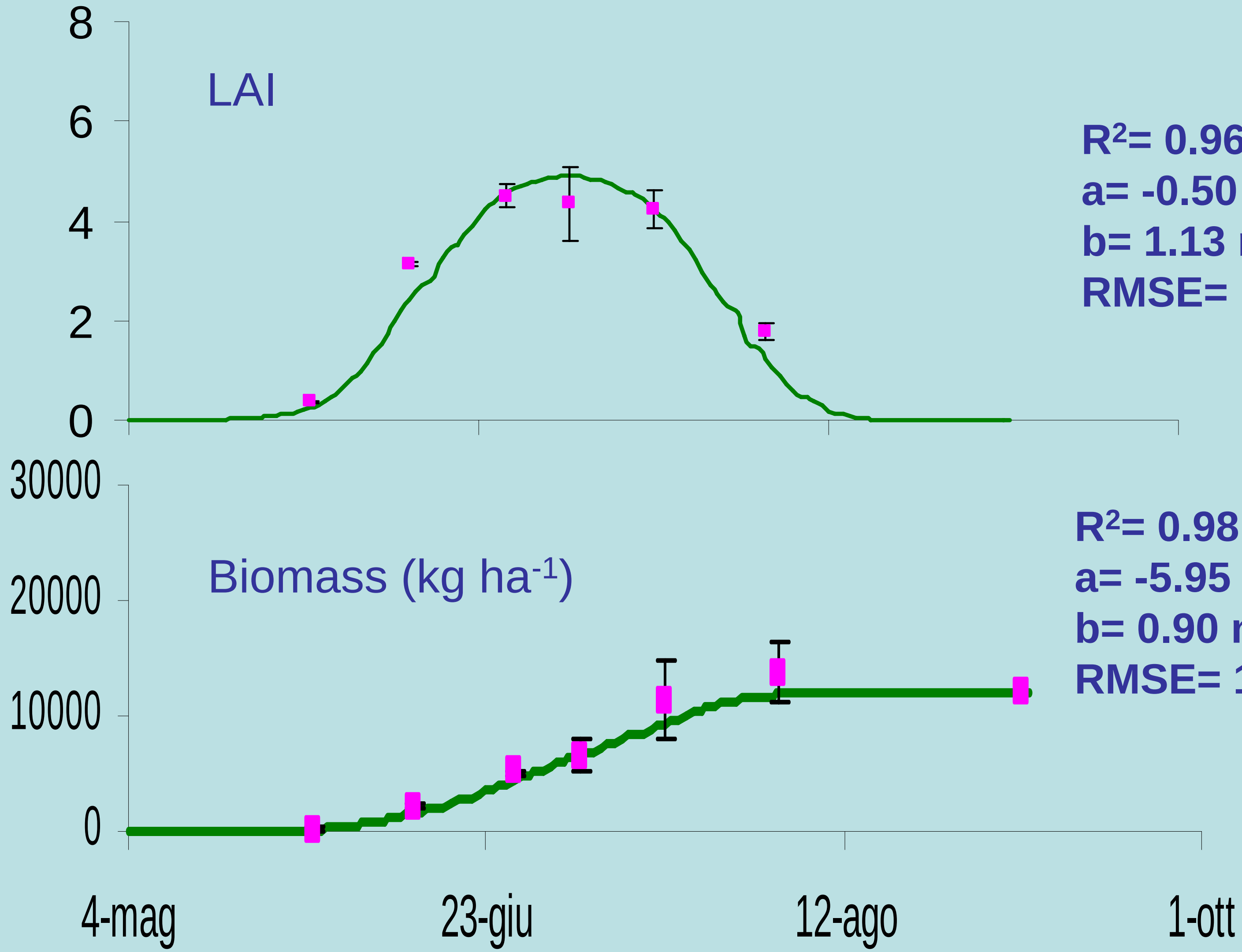
Cycle: **spring - summer**

Date of sowing : **01 may**

Date of harvesting: **7 september**

Type of soil: **clay**

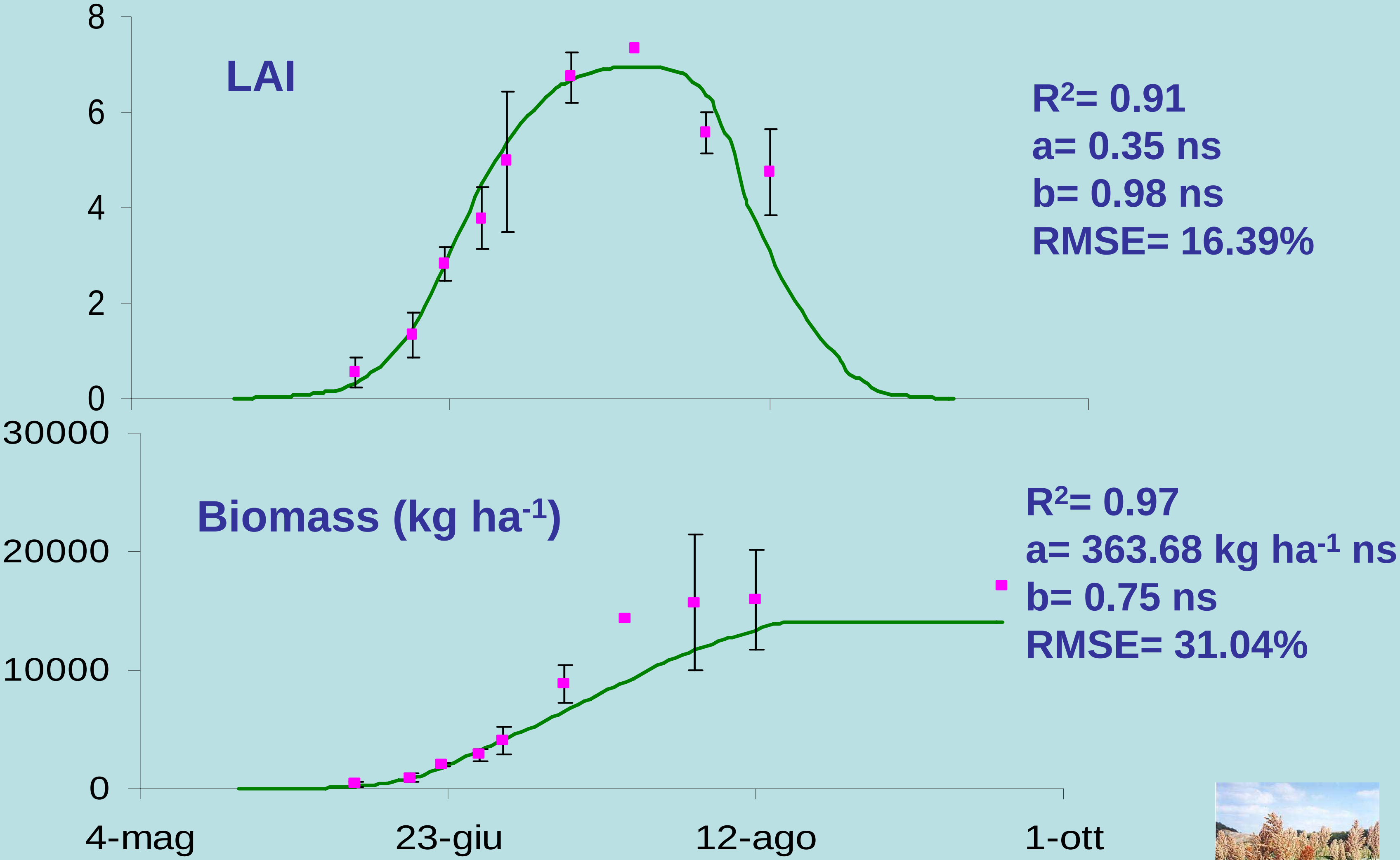
The calibration for sorghum in 2000



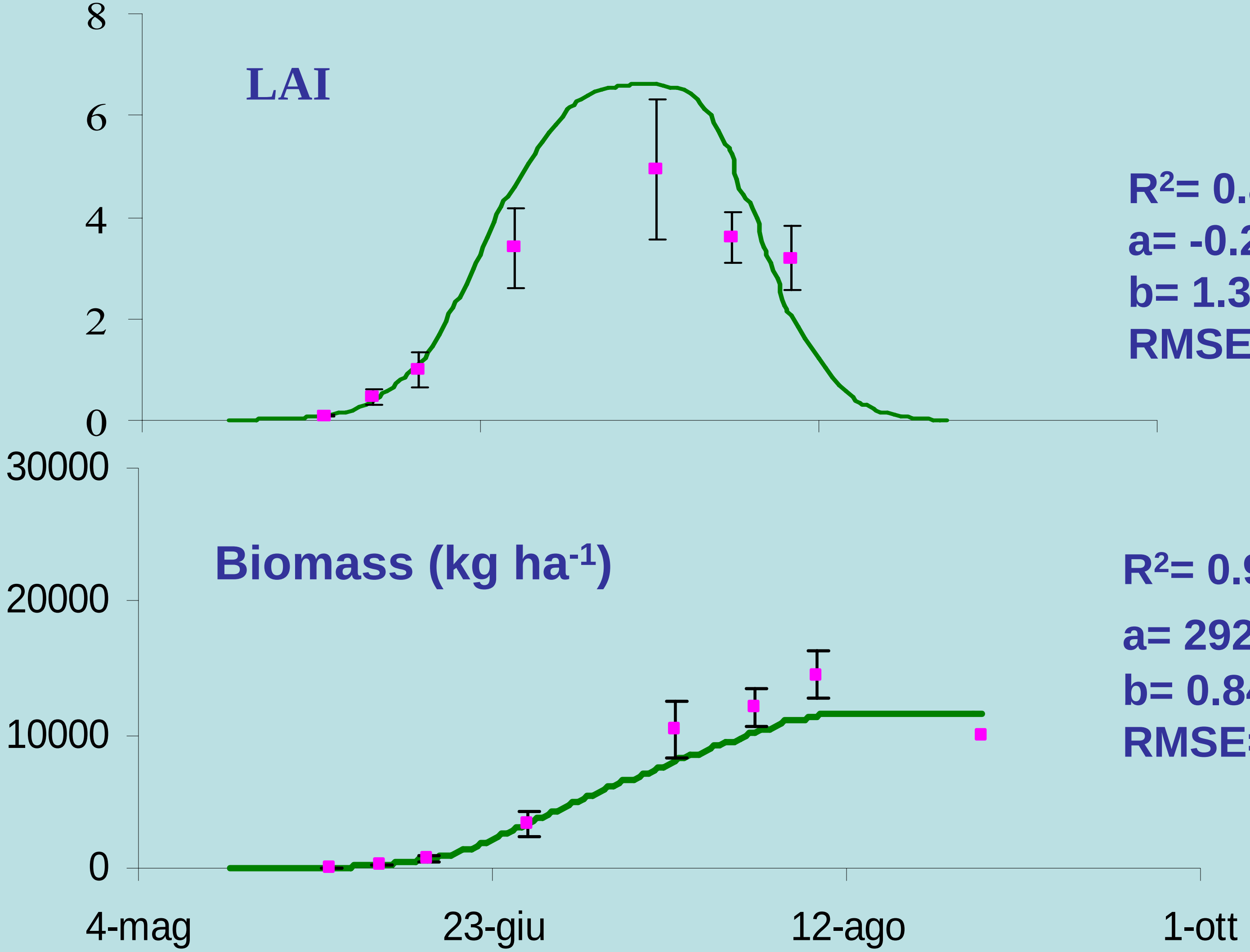
R^2= 0.96
a= -0.50 ns
b= 1.13 ns
RMSE= 14.14%

R^2= 0.98
a= -5.95 kg ha^{-1} ns
b= 0.90 ns
RMSE= 15.24%

The validation for sorghum in 1993



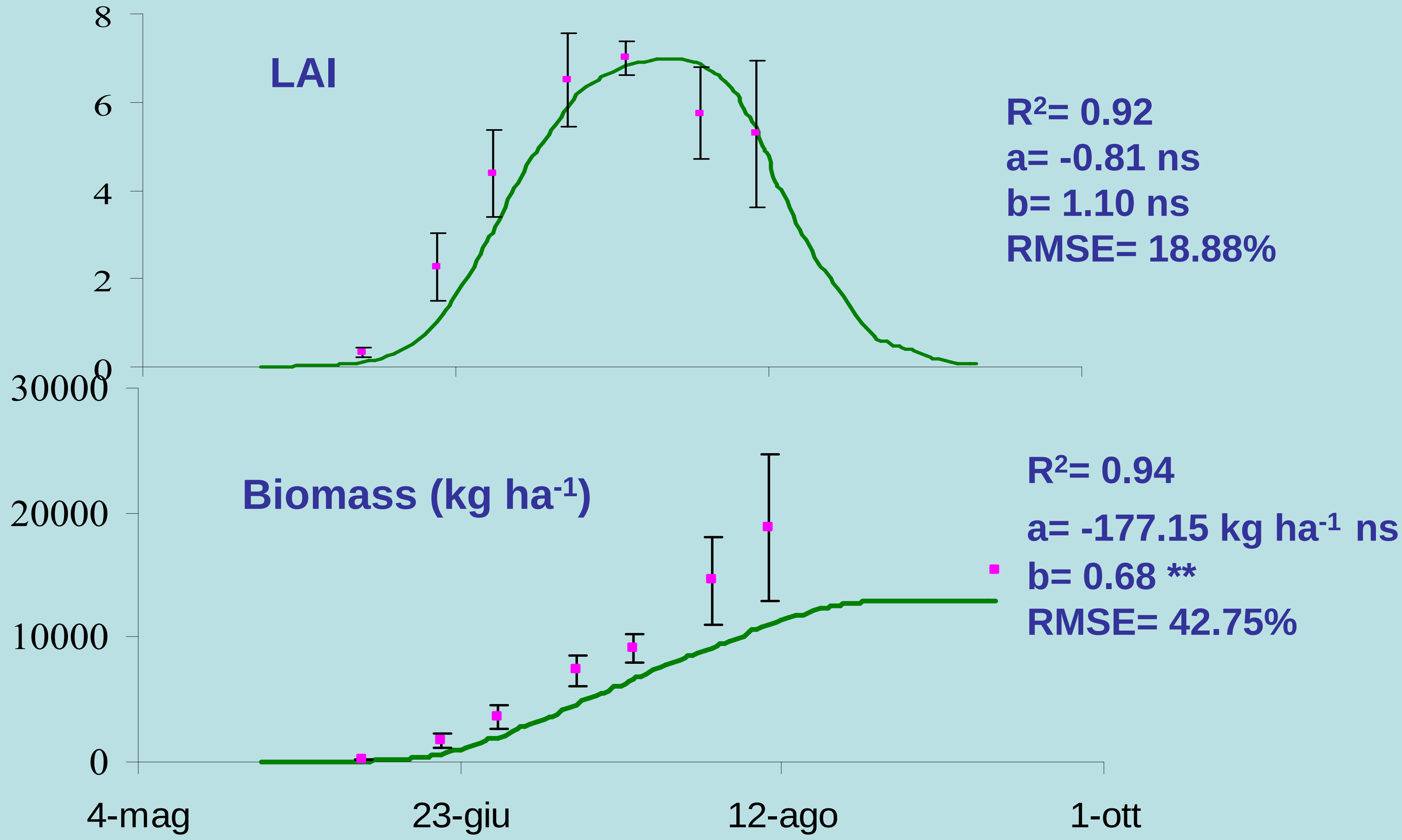
The validation for sorghum in 1994



R^2= 0.89
a= -0.28 ns
b= 1.32 ns
RMSE= 45.64%

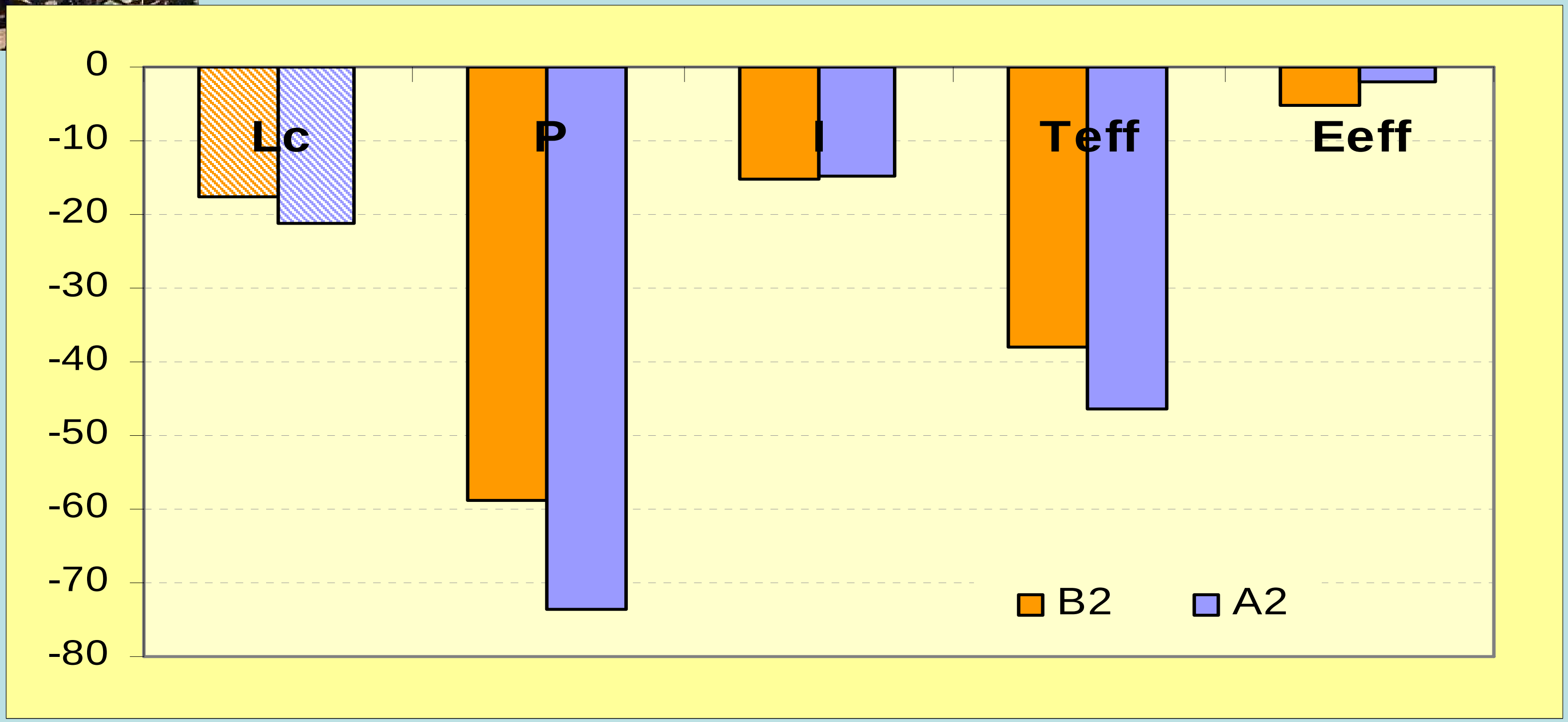
R^2= 0.94
a= 292.20 kg ha^{-1} ns
b= 0.84 ns
RMSE= 25.71%

The validation for sorghum in 1995



Water Balance for Sorghum cultivation

$$\Delta = 100\frac{Y_{future} - Y_{past}}{Y_{past}}$$



Lc=cycle lenght

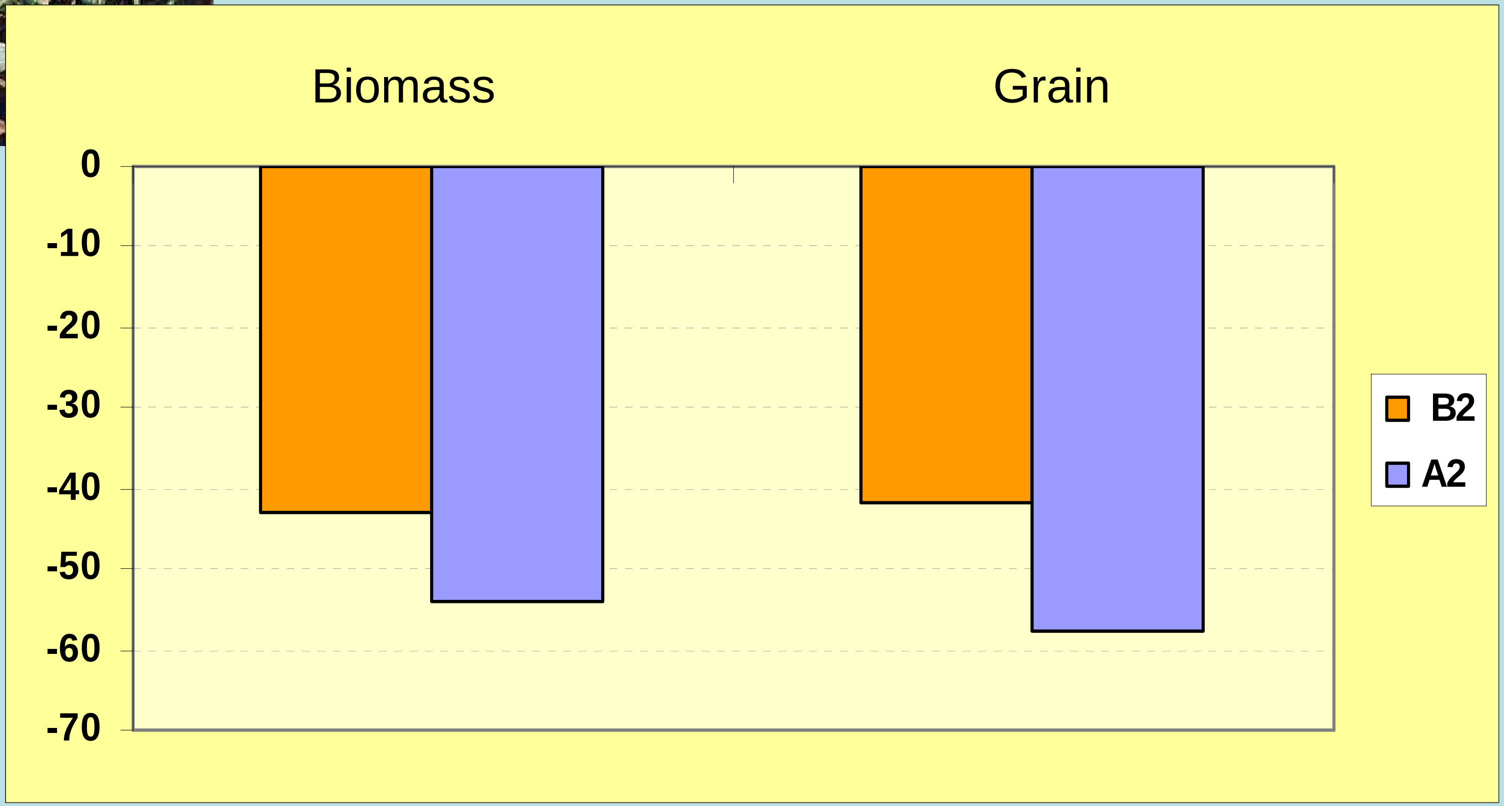
P=precipitation

I=Irrigation

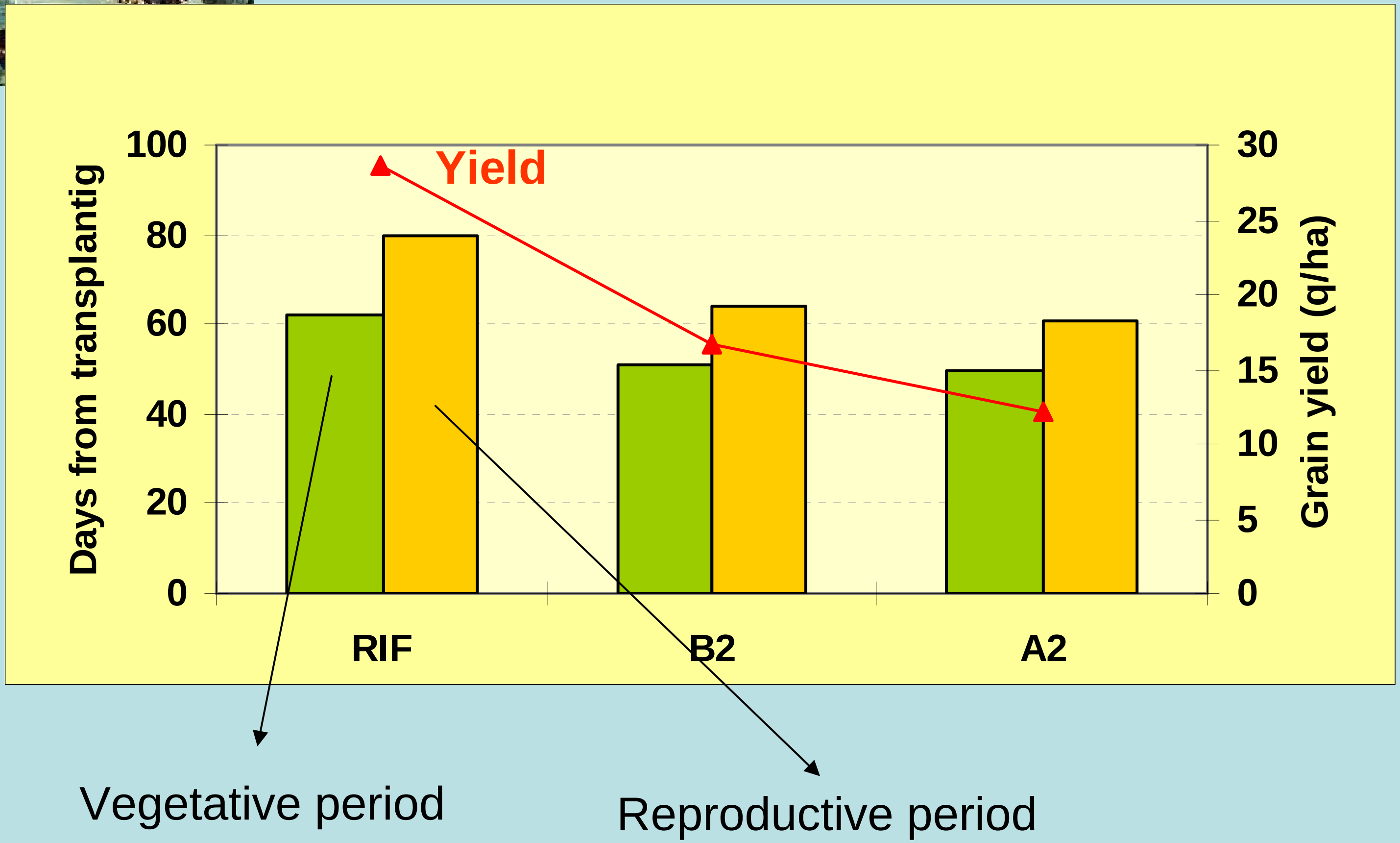
Teff=Actual Transpitration

Eeff=Actual Evaporation

The Yield of Sorghum



The cycle of Sorghum



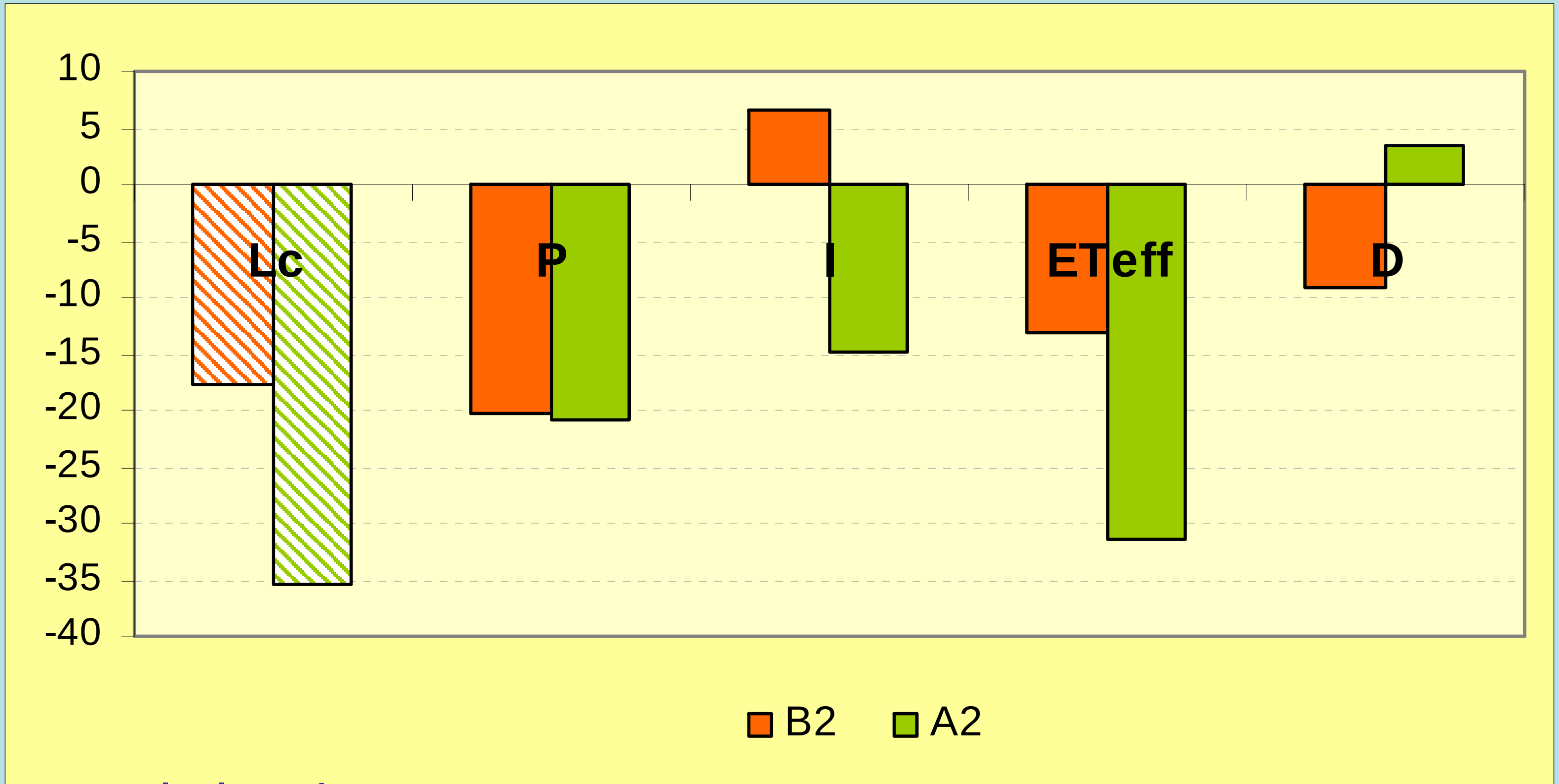
Scarola (*Cichorium endivia* var. *latifolium* Hegi cv Grovers Giant)

- **Cycle:** **winter**
- **Date of transplantig:** **15 October**
- **Date of harvest:** **3 March**
- **Soil:** **sand**

SWAP WITH SIMPLE METHOD TO SIMULATE CROP GROWTH

Scarola: WINTER LETTUCE

Water Balance



Lc=cycle lenght

P=precipitation

I=Irrigation

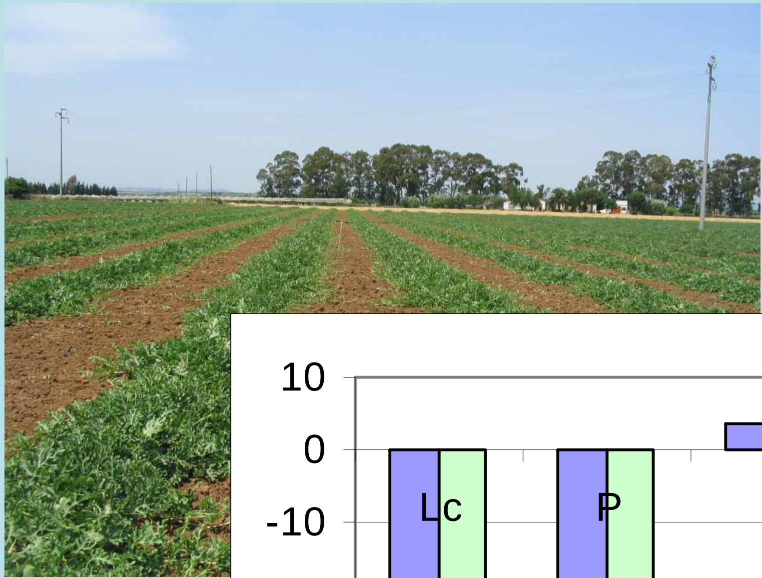
ETeff=Actual Evapotranspiration

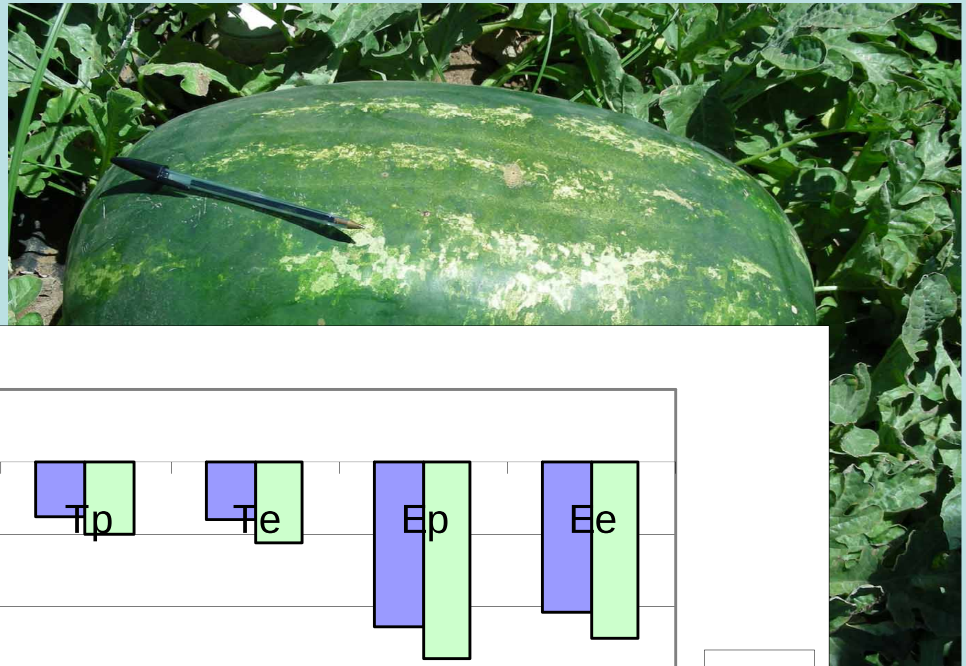
D=Drainage

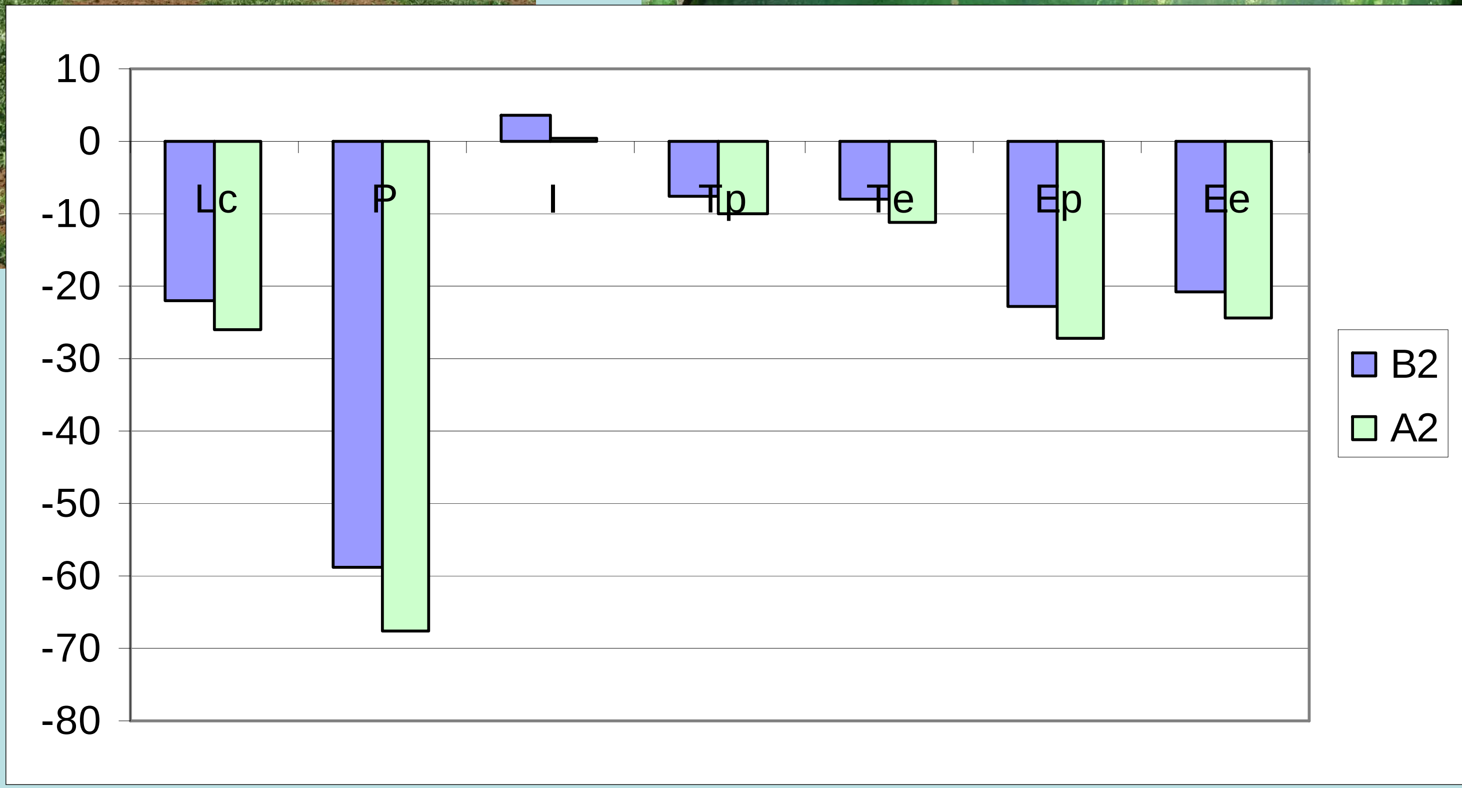



The Water melon cultivation in Southern Italy

- Transplanting time: end of march – April
- Inter-row of 2.5-3 m – plant every 1-1.5 m
- Black Plastic Film of 0.50 m
- Drip irrigation
- Tunnel with transparent and plastic film in the first month of cultivation to bring forward the crop growth







Lc=cycle lenght

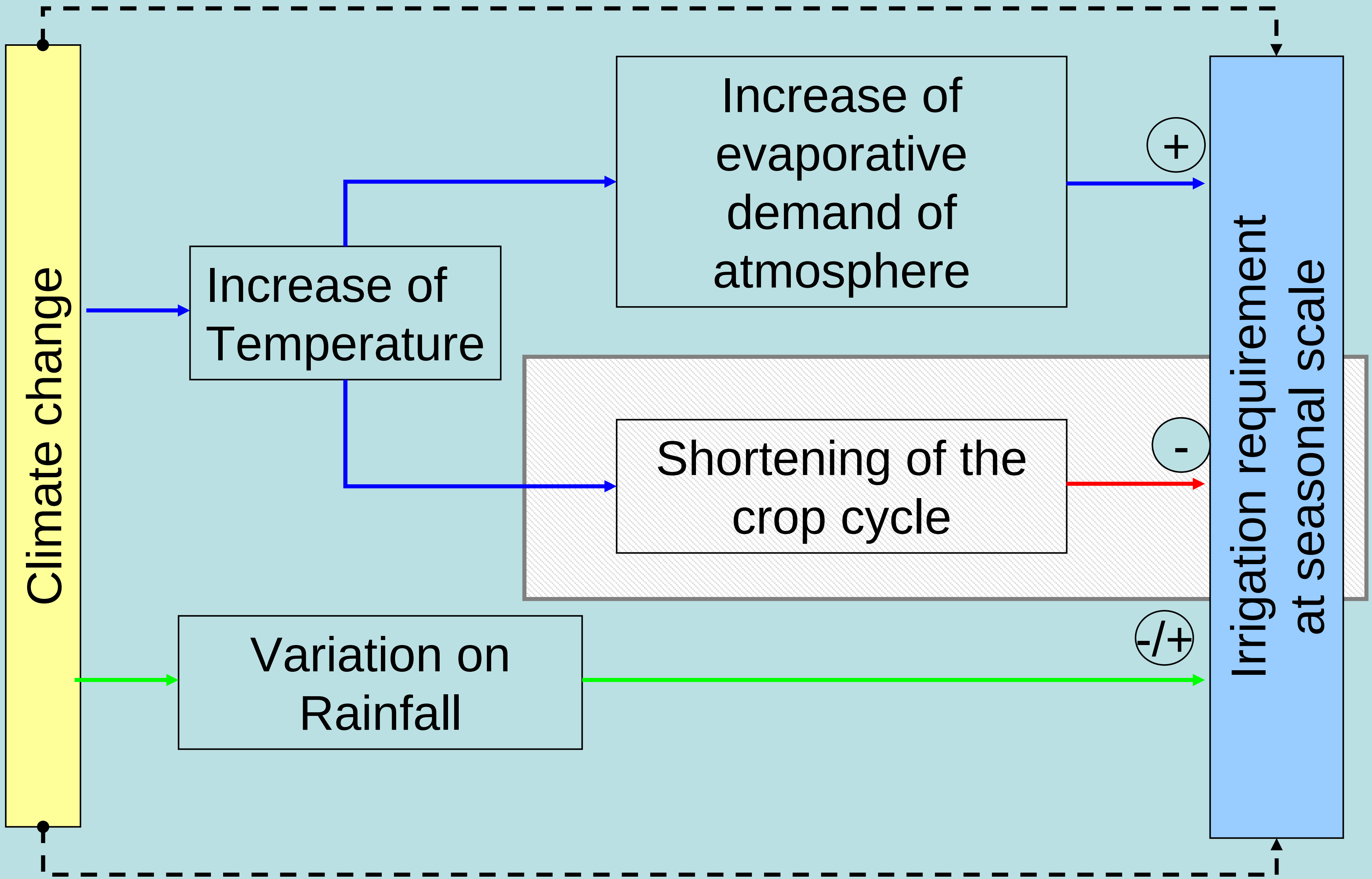
P=precipitation

I=Irrigation

T = Transpiration

E=Evaporation

D=Drainage


Climate change
Increase of Temperature
Increase of evaporative demand of atmosphere
+
Shortening of the crop cycle
-
Variation on Rainfall
-/+
Irrigation requirement at seasonal scale

CONSIGLIO PER LA RICERCA E LA SPERIMENTAZIONE IN AGRICOLTURA

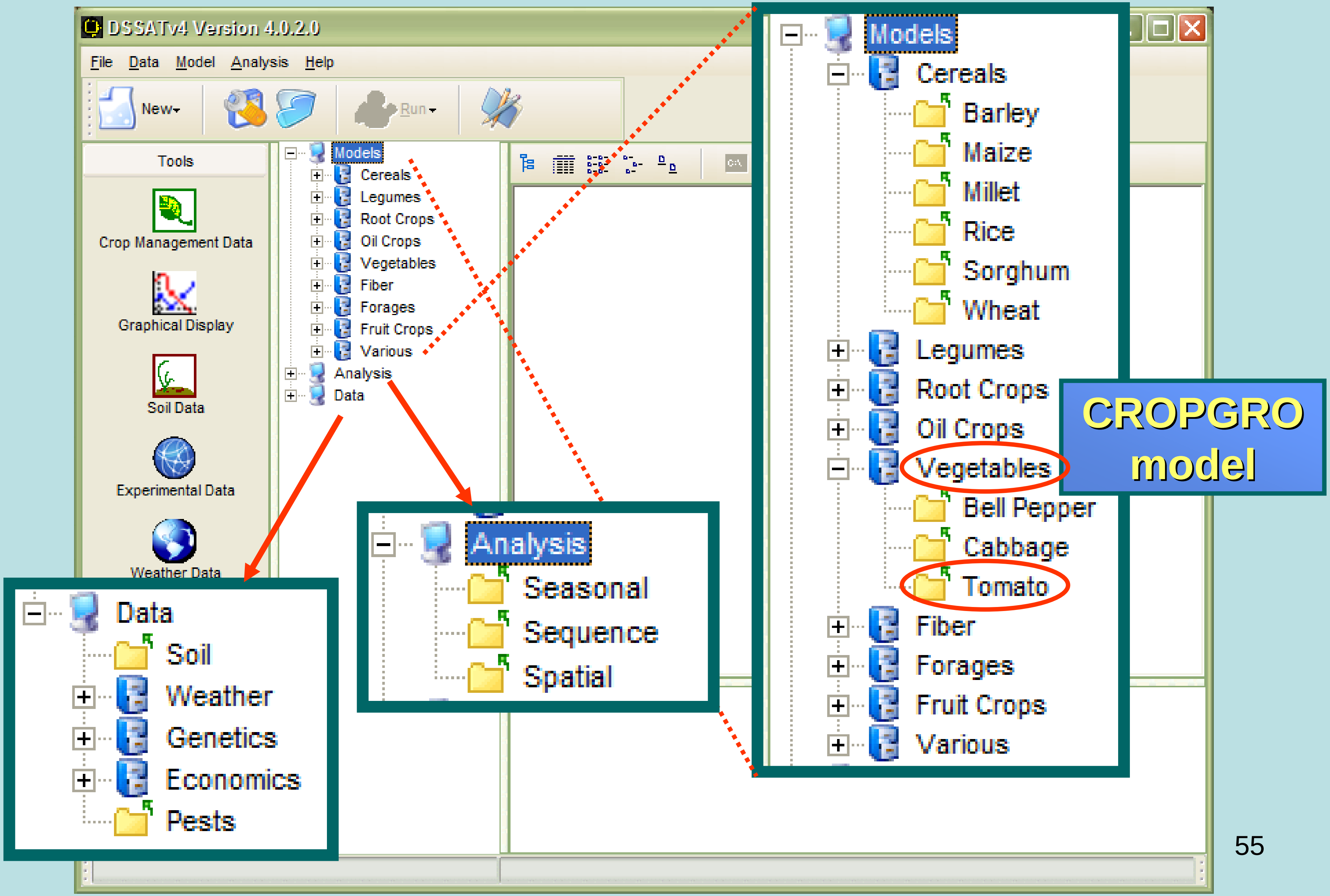
VULNERABILITY OF TOMATO TO CLIMATE CHANGE IN PUGLIA

Michele Rinaldi and Domenico Ventrella

Consiglio per la Ricerca e Sperimentazione in Agricoltura
Unità di Ricerca per i sistemi colturali degli ambienti caldo-aridi,
ex-Istituto Sperimentale Agronomico di Bari

The area of reference:

DSSAT 4.0.2.0



DSSATv4 Version 4.0.2.0
File Data Model Analysis Help
New
Run
Tools
Crop Management Data
Graphical Display
Soil Data
Experimental Data
Weather Data
Models
Cereals
Legumes
Root Crops
Oil Crops
Vegetables
Fiber
Forages
Fruit Crops
Various
Analysis
Data
Models
Cereals
Barley
Maize
Millet
Rice
Sorghum
Wheat
Legumes
Root Crops
Oil Crops
Vegetables
Bell Pepper
Cabbage
Tomato
Fiber
Forages
Fruit Crops
Various
CROPGRO model
Analysis
Seasonal
Sequence
Spatial
Data
Soil
Weather
Genetics
Economics
Pests

CO_2 and CROPGRO

Photosynthesis at leaf scale

Upscaling

Sub-model

Photosynthesis at canopy scale

Model that simulates the relationships between

Photosynthesis

Water balance

Canopy energy balance

Relationship between Co_2 and water balance

Water stress

Stomata closure

Reduction of flux of CO_2 in the canopy

Reduction of Photosynthes is rate

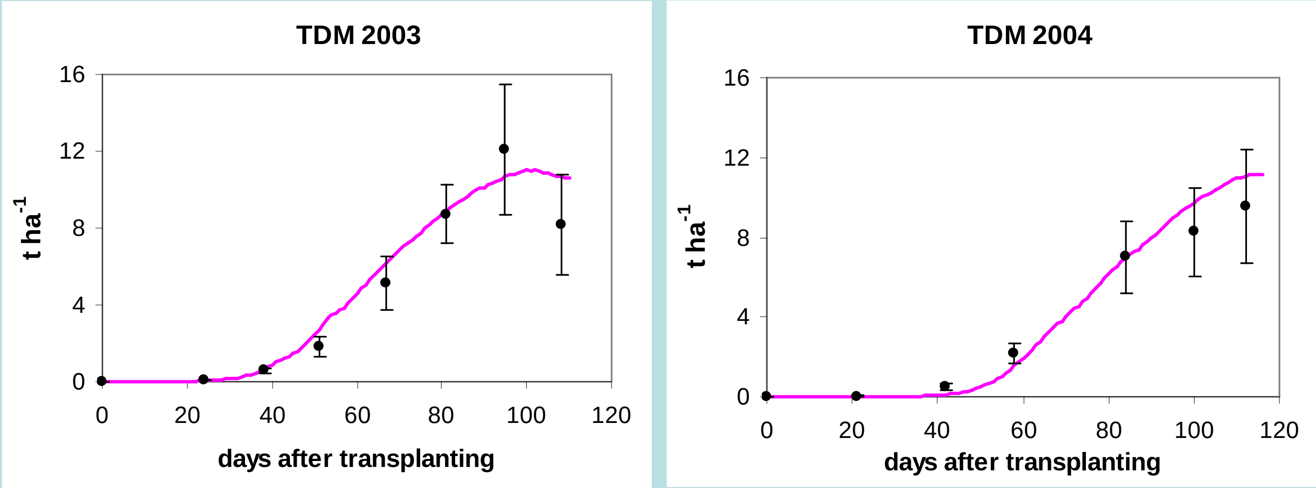
High [CO_2]

Stomata closure

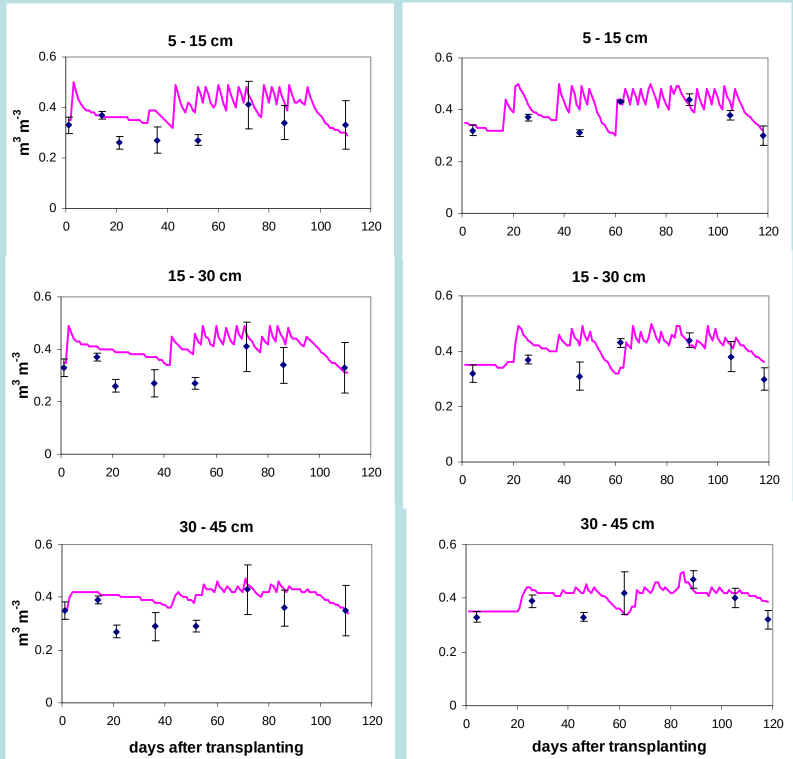
Decrease of plant transpiration

The calibration of CROPGRO

For biomass



For soil water content



Tomato simulated with CROPGRO model

Genotype: ibrid PS 1296

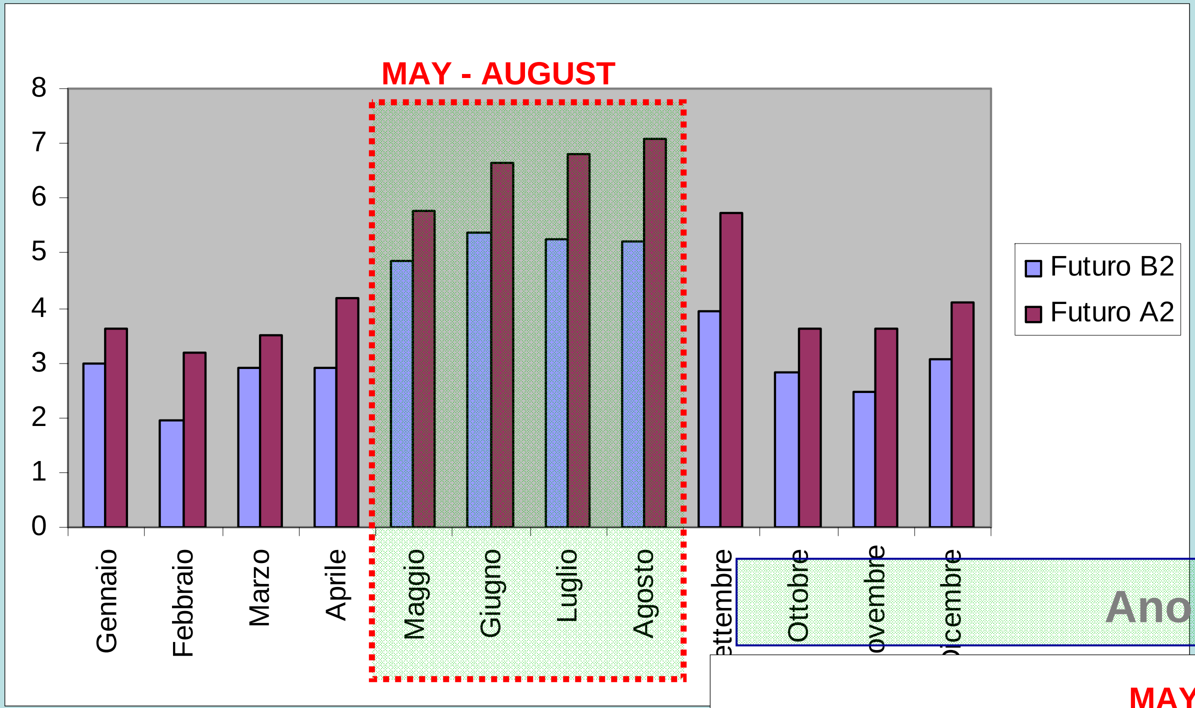
Soil: silt-clay soil

Transplantig time: first of May

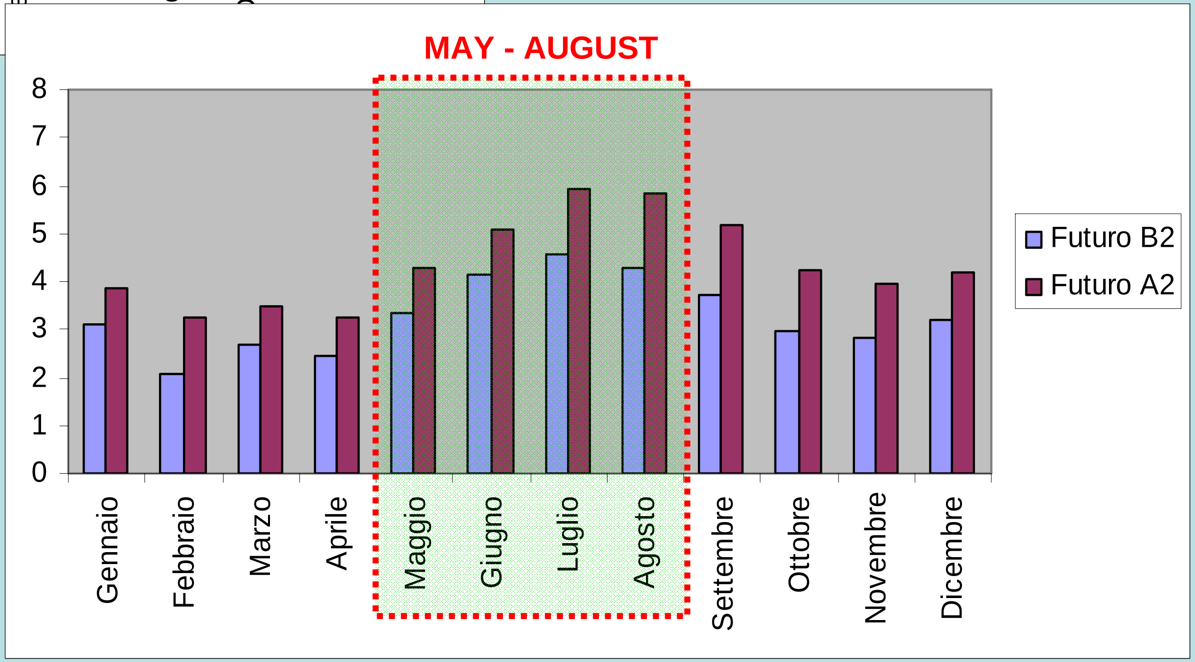
Harves tyme: half of August

Typical irrigation: localized method

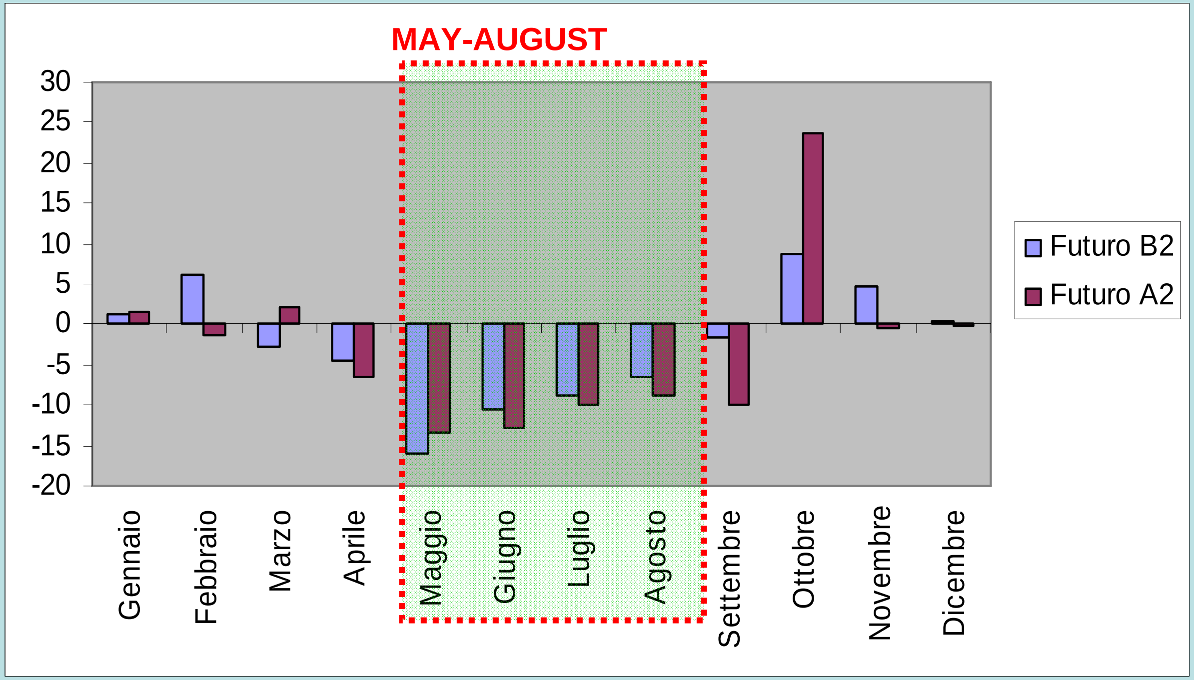
Anomalies of T MAX



Anomalies of T MIN



Anomalies of precipitation (mm)



Simulations with CROPGRO

Simulations:

- Potential

- With automatic irrigation

×

Climatic series:

- Past

- Future B2

- Future A2

1) Without CO_2 effect

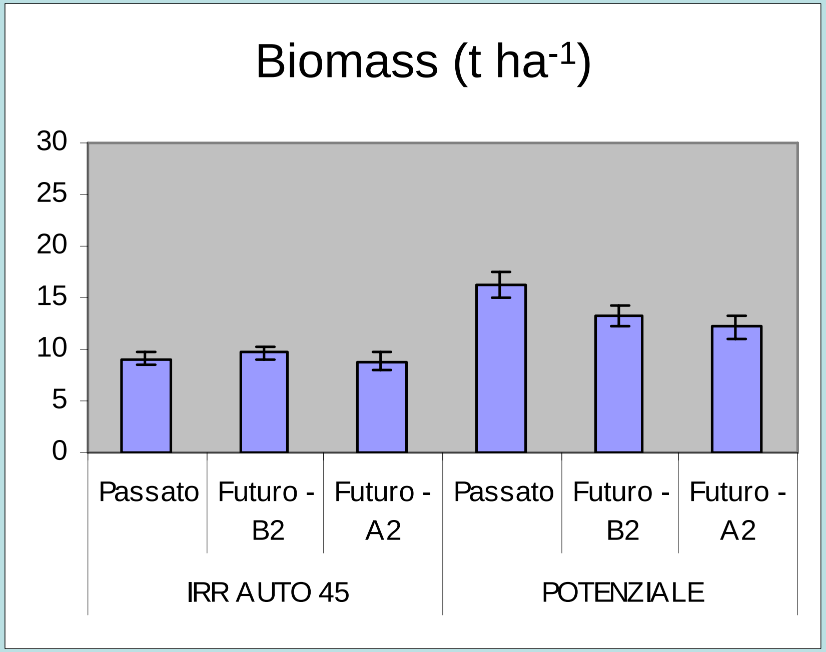
(**Simulation 1**)

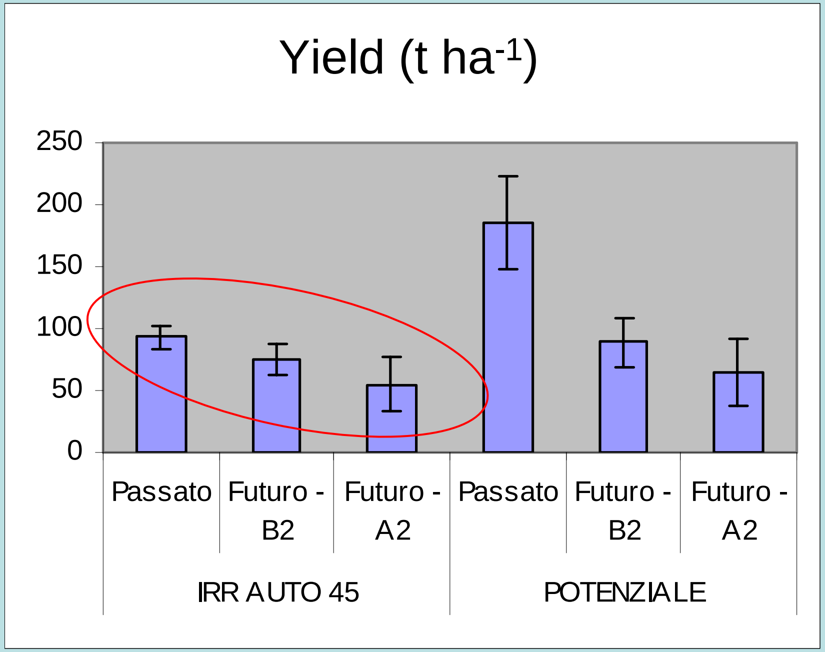
2) With effect of CO_2

(**Simulation 2**)

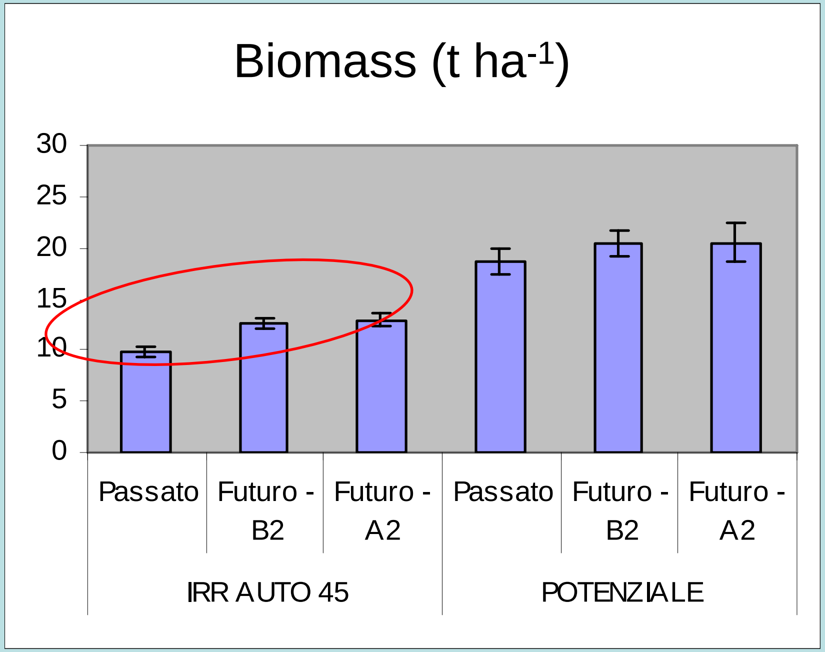
Results

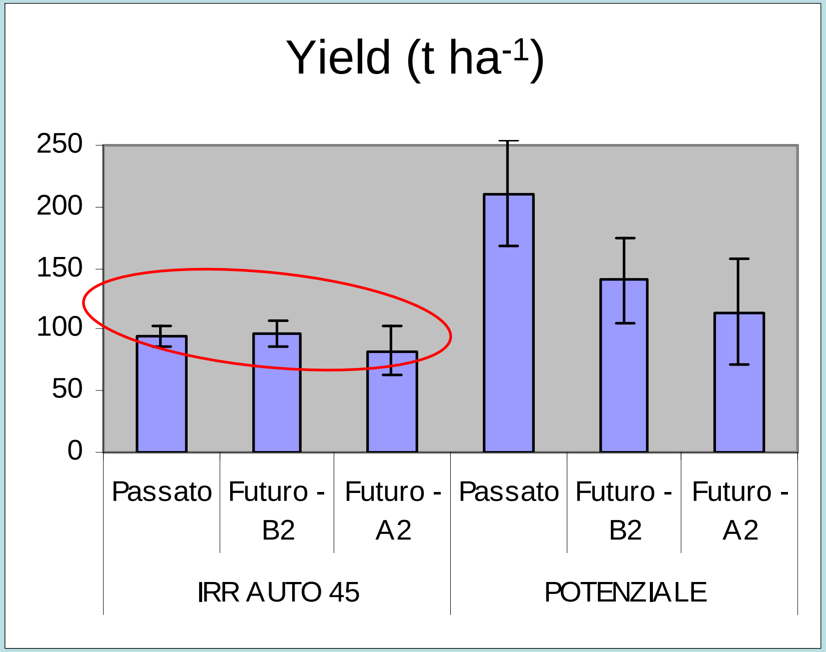
Simulation 1 (without CO2)



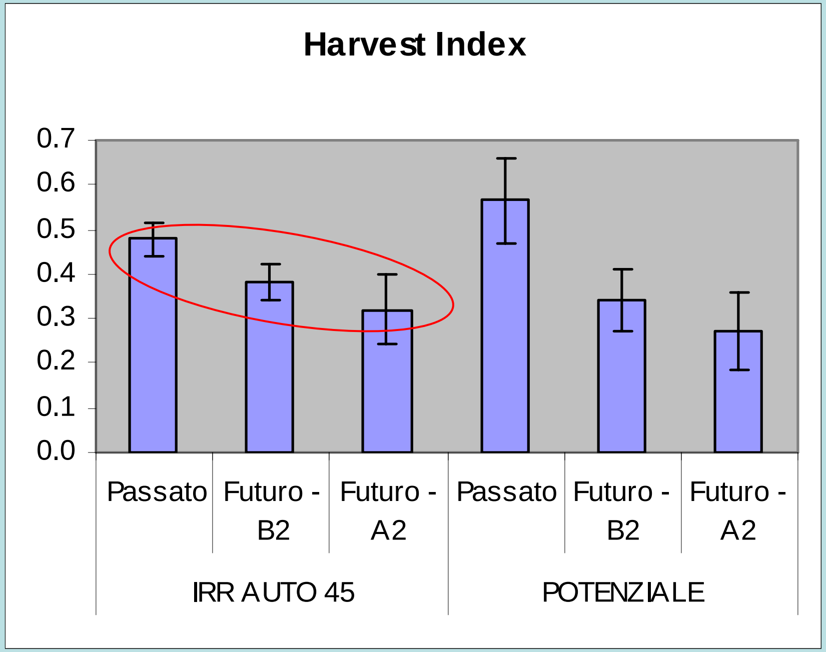


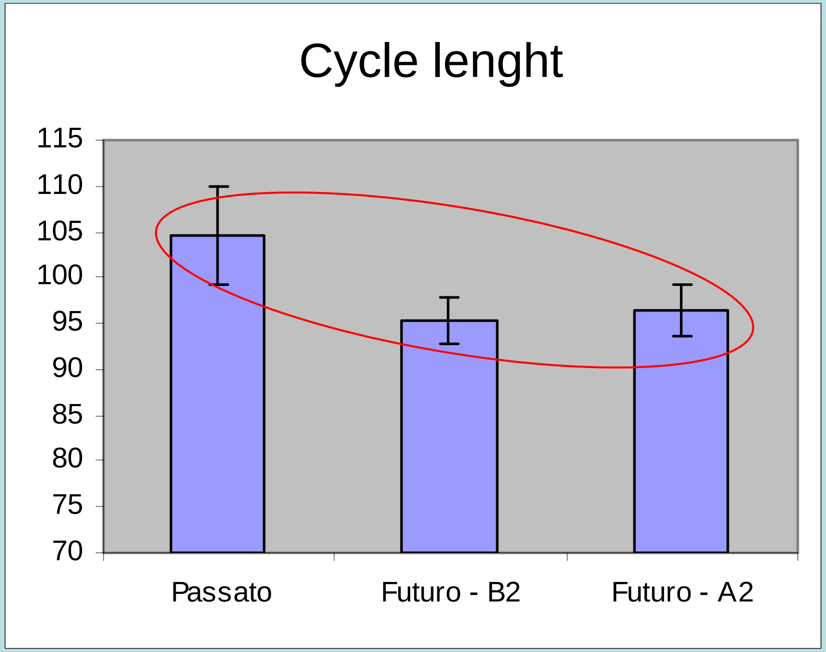
Simulation 2 (with $[CO_2]$)

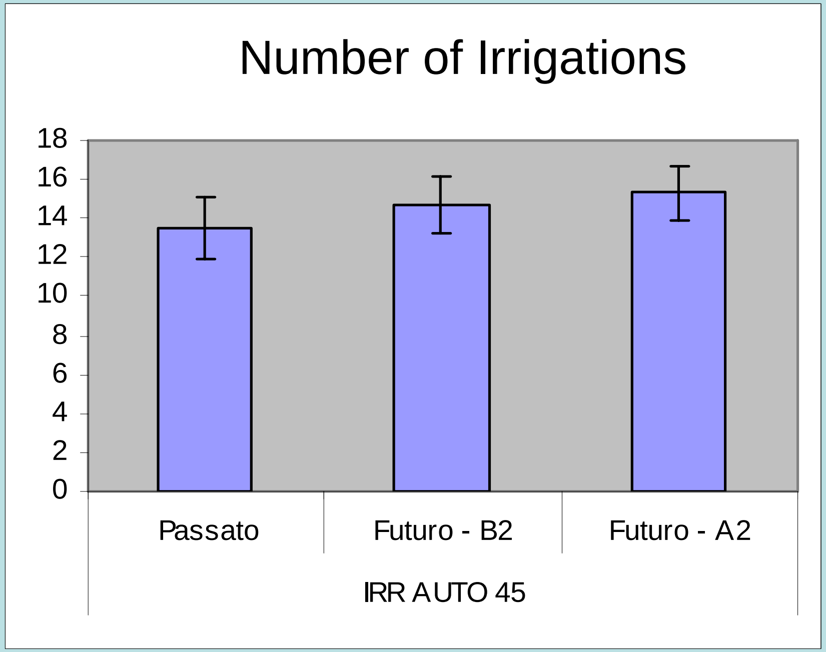


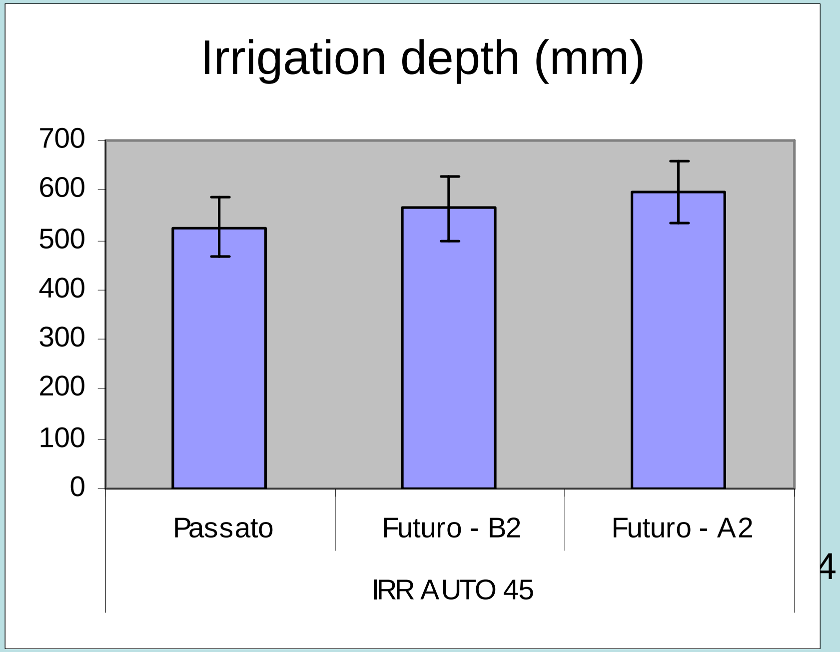


Simulazione 2 (with [CO_2])









CONCLUSIONS

The shortening of cycle, because of warming, determines very significant effects for Sorghum, Scarola and Water melon causing reduction of rainfall, ET and yield (Sorghum). The variations of irrigation requirements are less consistent ranging from -15 to +5%.

Tomato, a C3 plant with a spring-summer cycle, has been simulated according taking and no-taking in account the CO_2 effect
No taking in account the CO_2 the climate change for A2 and B2 determined shortening of cycle, increasing of water use, and yield, WUE and WUEIRR

Taking in account the CO_2 overcomes the negative effect of Climate Change on tomato yield

Outlook to WP3

1) Carry out the regional pilot assessment in order to define agronomic adaptation strategies by means of climate scenario analysis and modelling approach. The candidate agronomic practices will be:

- Early sowing (or transplanting) times
- Adoption of varieties with longer cycle
- Irrigation strategies to save water and increase the Wtaer Use Efficiency
- Supplemental Irrigation for rainfed-crop (winter wheat)
- Possibility of extending the crop season to include other crops (if the water irrigation is not a limiting factor)

Outlook to WP3

2) Above all for tree crops, to analyze available studies in national and international literature regarding the ongoing and feasible potential adaptation measures on selected and representative agroecosystems in Italy (Puglia/Basilicata regions and Emilia-Romagna region)

3) Analysis of uncertainties, cost/benefits, risks, opportunities for co-benefits of adaptation measures