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POVRSTARSTVO



UNIVERSITÀ  
DEGLI STUDI  
FIRENZE  
**DISPAA**  
DIPARTIMENTO DI SCIENZE DELLE  
PRODUZIONI AGROALIMENTARI  
E DELL'AMBIENTE



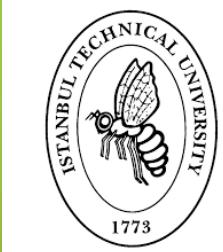
UNIVERSITÄT FÜR  
BODENKULTUR  
WIEN  
**BOKU**  
DEPARTMENT FÜR WASSER-  
ATMOSPHARE-UMWELT



EUROPEAN  
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**Horizon 2020**  
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FOR RESEARCH & INNOVATION

**Summer School  
2017**

$A_g M_{net}$  + **INTERNATIONAL SUMMER SCHOOL IN  
AGROMETEOROLOGY AND CROP MODELLING**  
**2017**



# Introduction

## Evapotranspiration: Methods and Application

**Levent SAYLAN**  
**Prof.Dr.**

*Istanbul Technical University  
Department of Meteorology  
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# CONTENT

- Who am I?
- What are we doing on agricultural meteorology in my country?
- Examples

# **Agricultural, Forest- and Hydrometeorology Research Group**

**Department of Meteorology,  
Faculty of Aeronautics and  
Astronautics, Istanbul Technical  
University**

Professor of Meteorology

Istanbul Technical University Faculty of Aeronautics and Astronautics Dept. of Meteorology, Maslak,  
34469, Istanbul-Turkey

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## Education

- **1993** **Ph.D.** University of Natural Resources and Life Sciences (BOKU),  
Dept. of Meteorology and Physic Vienna, Austria  
Major Field: Agricultural Meteorology  
Minor Field: Micrometeorology, Evapotranspiration, Crop-Growth Simulation Models
- Certificate of German Language Center of Goethe Institute
- Certificate of Intensive English Program, University of Ankara, Ankara, Turkey
- **1989** **M.Sc.** University of Ankara, Ankara, Turkey  
Major Field: Agricultural Engineering
- **1986** **B.Sc.** University of Ankara, Ankara-Turkey  
Major Field: Agricultural Engineering
- **1982** **Diploma of High School**, Kırklareli Atatürk High School, Kırklareli-Turkey

# Research Interests

- Terrestrial ecosystem
- Ecosystem gas exchange (CO<sub>2</sub>, CH<sub>4</sub> ....)
  - Measurement
  - Analyses
  - Modelling
- Impacts of climate change on agriculture, forest and water resources
- Drought
- Evapotranspiration

# **ASSESSMENT OF RELATIONSHIP BETWEEN WINTER WHEAT CARBON EXCHANGE AND VEGETATION DYNAMICS**

**Prof.Dr. Levent SAYLAN  
Meteorol. Eng. Elif SEMIZOGLU  
Dr. Baris CALDAG  
MSc Sezel KARAYUSUFOGLU**

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Aeronautics and Astronautics, Istanbul  
Technical University  
Istanbul, Turkey**



**11th EMS Annual Meeting  
10th European Conference on Applications of Meteorology (ECAM)  
12 - 16 September 2011  
Berlin, Germany**

# Subject of study

- Investigate relationships between carbon fluxes and vegetation dynamics in order to estimate carbon fluxes on wide areas in Thrace region of Turkey for the first time.

# Research Area -Site Description



The research project was carried out over a winter wheat field in Kırklareli city located in the Thrace Region of Turkey

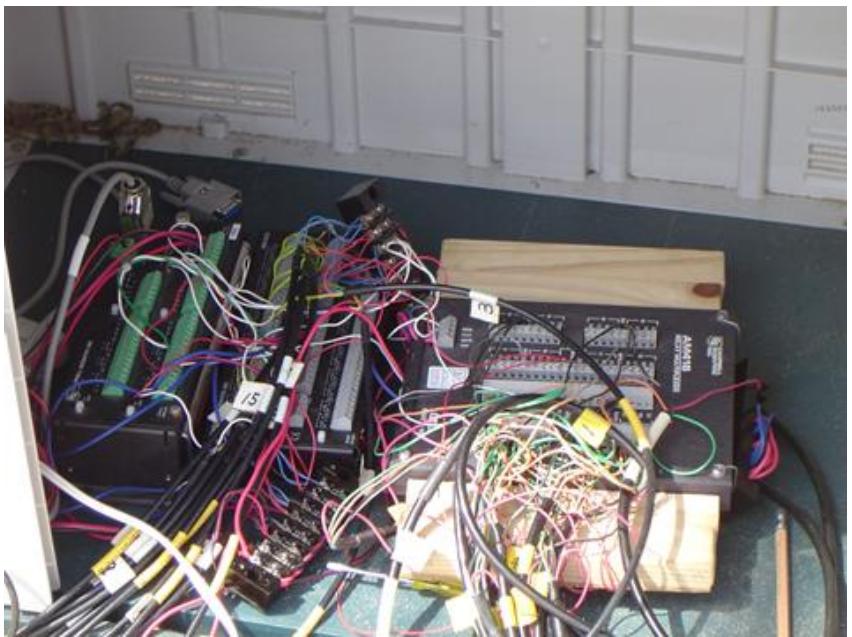
<sup>1</sup> Eddy Covariance Measuring System

<sup>2</sup> Agrometeorological Station

# Experiments and Observations



WINTER WHEAT PHENOLOGICAL OBSERVATIONS	DATE
Planting	09.10.2009
Germination	17.10.2009
2. Leaf	21.10.2009
3. Leaf	26.10.2009
Tillering	25.11.2009
Stem Formation	31.03.2010
Earing	26.04.2010
Flowering	10.05.2010
End of flowering	24.05.2010
Grain filling	24.05.2010
Maturity	04.06.2010
Harvest	06.07.2010



# Flux studies



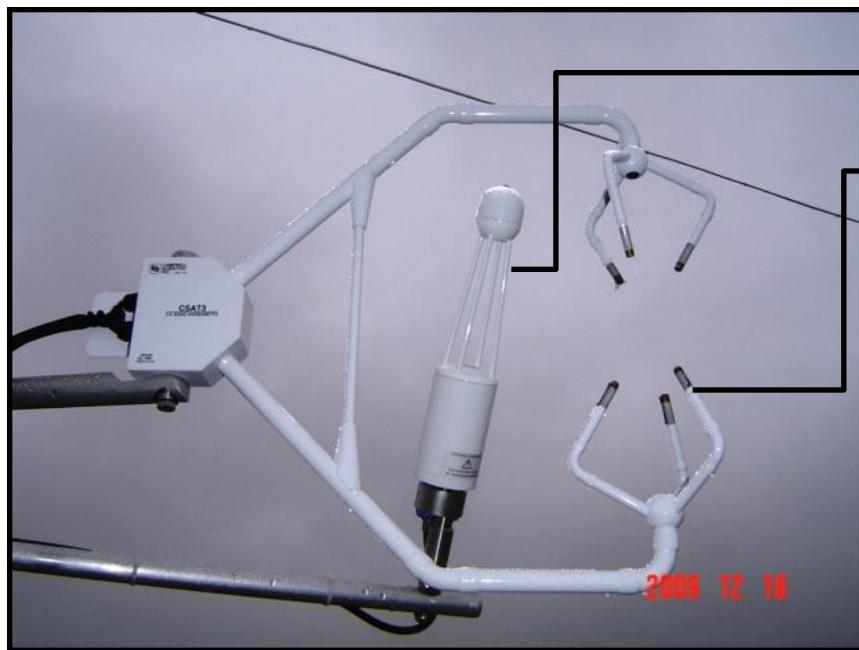
# CO<sub>2</sub> and H<sub>2</sub>O Flux



# Experiments and Observations (Contd.)



# METHODS-Eddy Covariance Measuring System

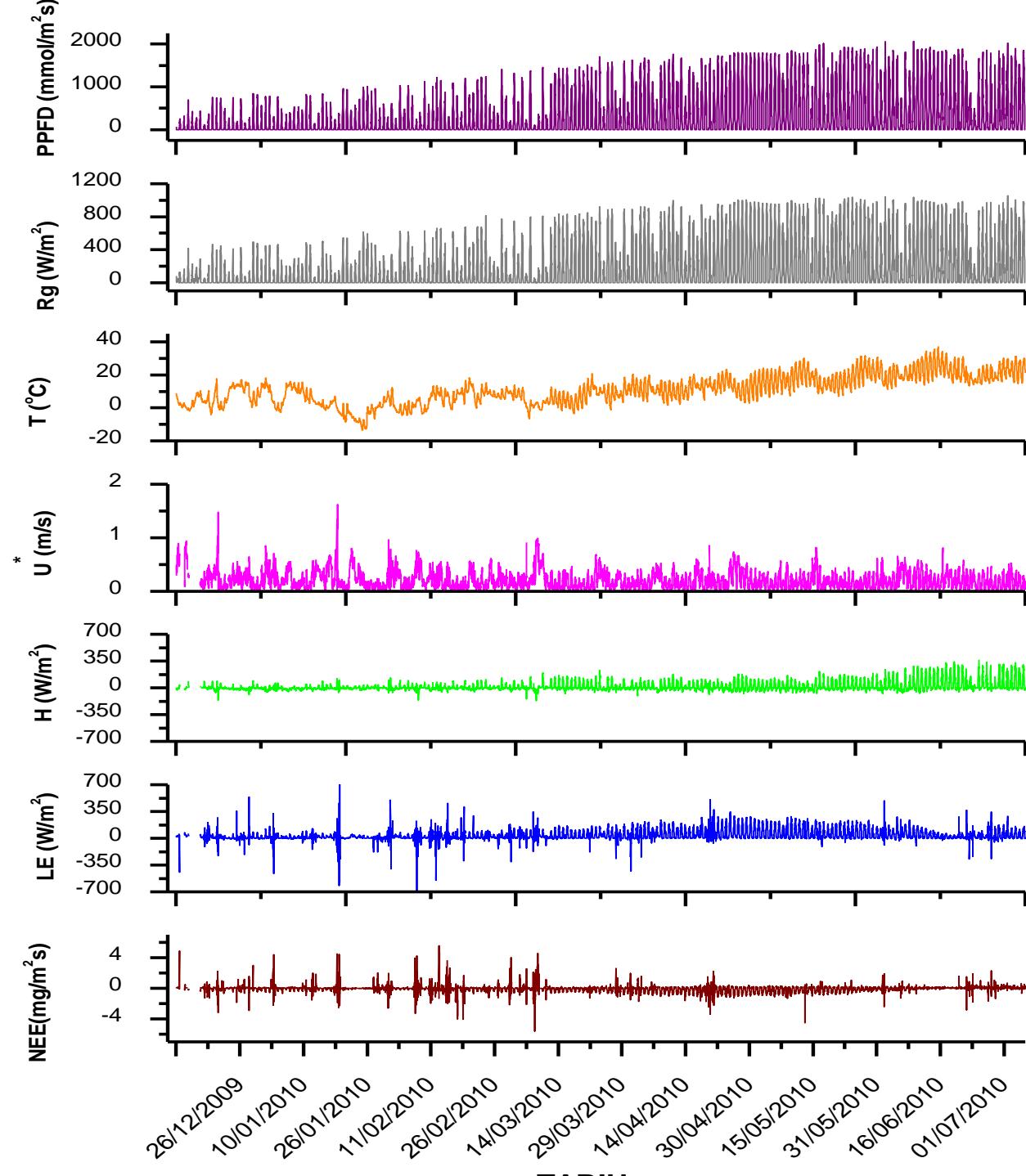


Open path infrared gas analyzer

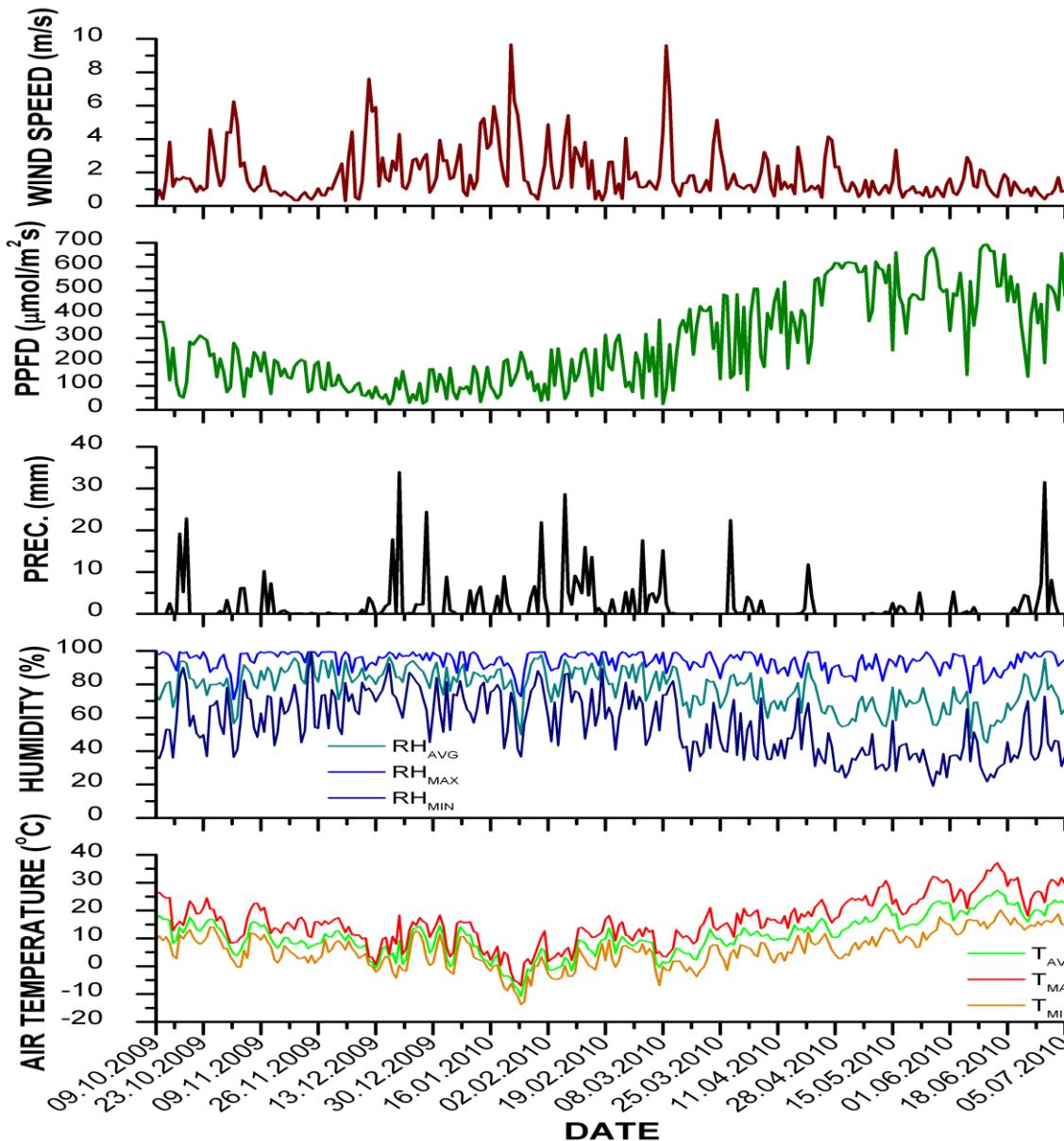
Three-dimensional sonic anemometer



Open Path Eddy Covariance System



# RESULTS&DISCUSSION



# Flux Corrections, Gap filling and Flux Partitioning

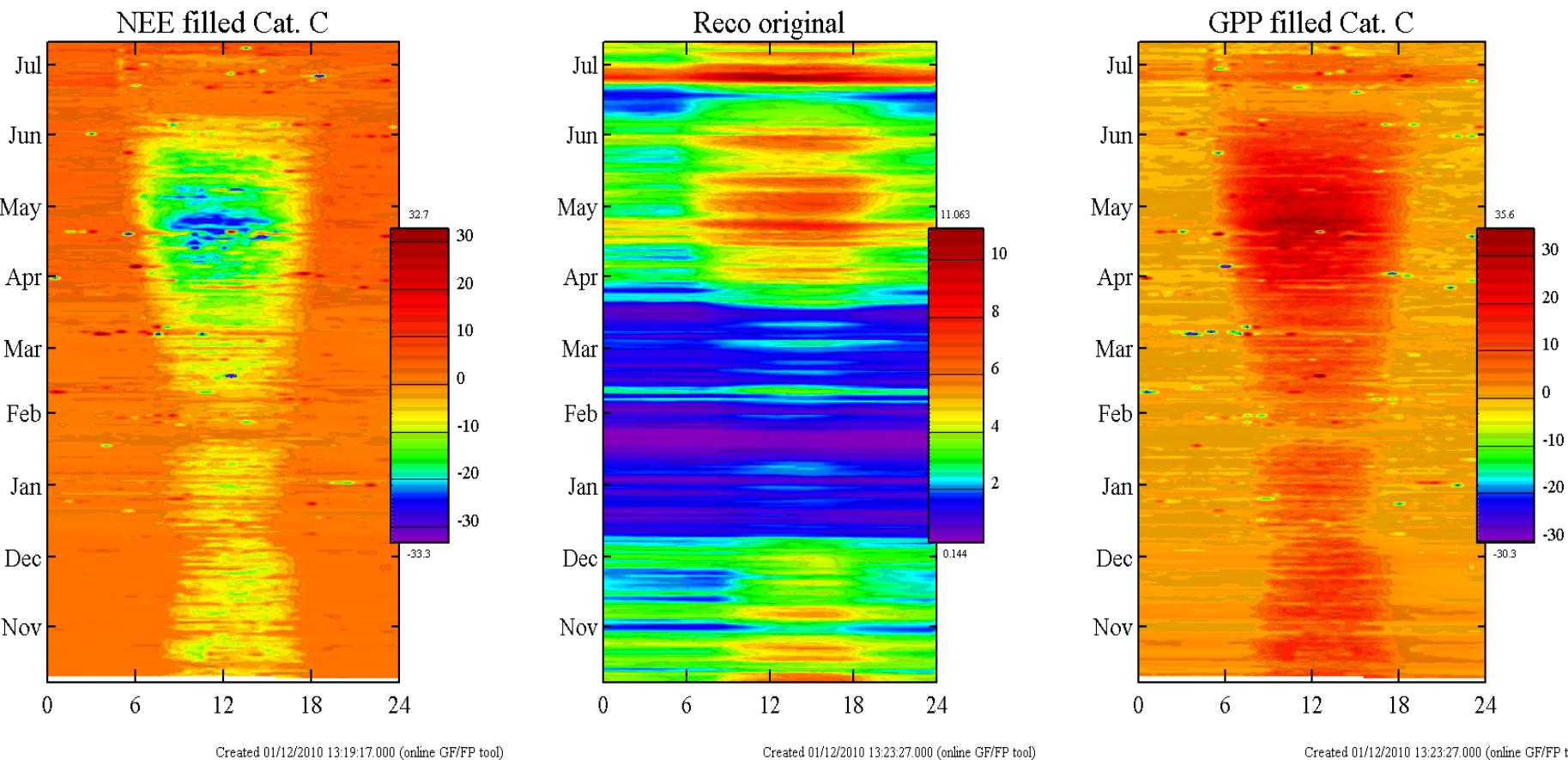
During the data processing;

- Spike Removal
- Frequency Response
- WPL (Webb, Pearman, Leuning)
- Coordinate Rotation Corrections have been applied to the EC data set.

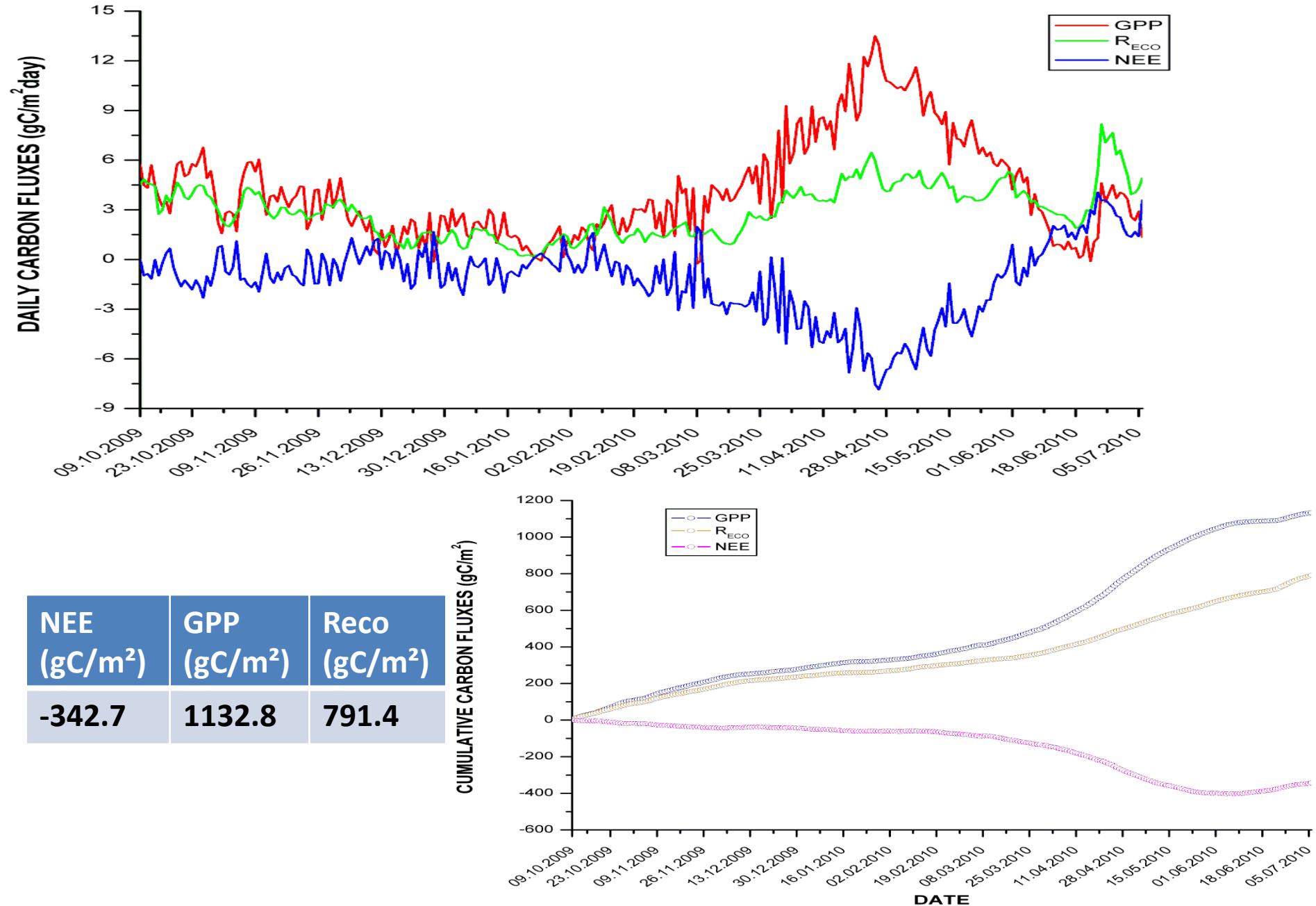
$$\text{NEE} = \text{R}_{\text{eco}} - \text{GPP}$$



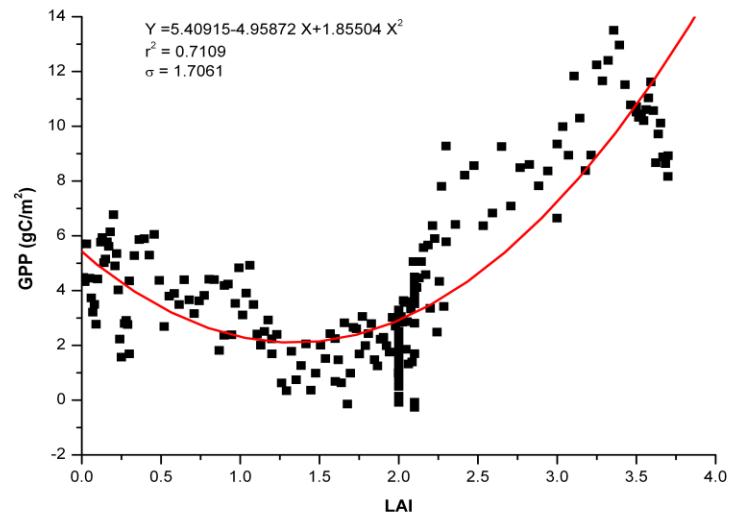
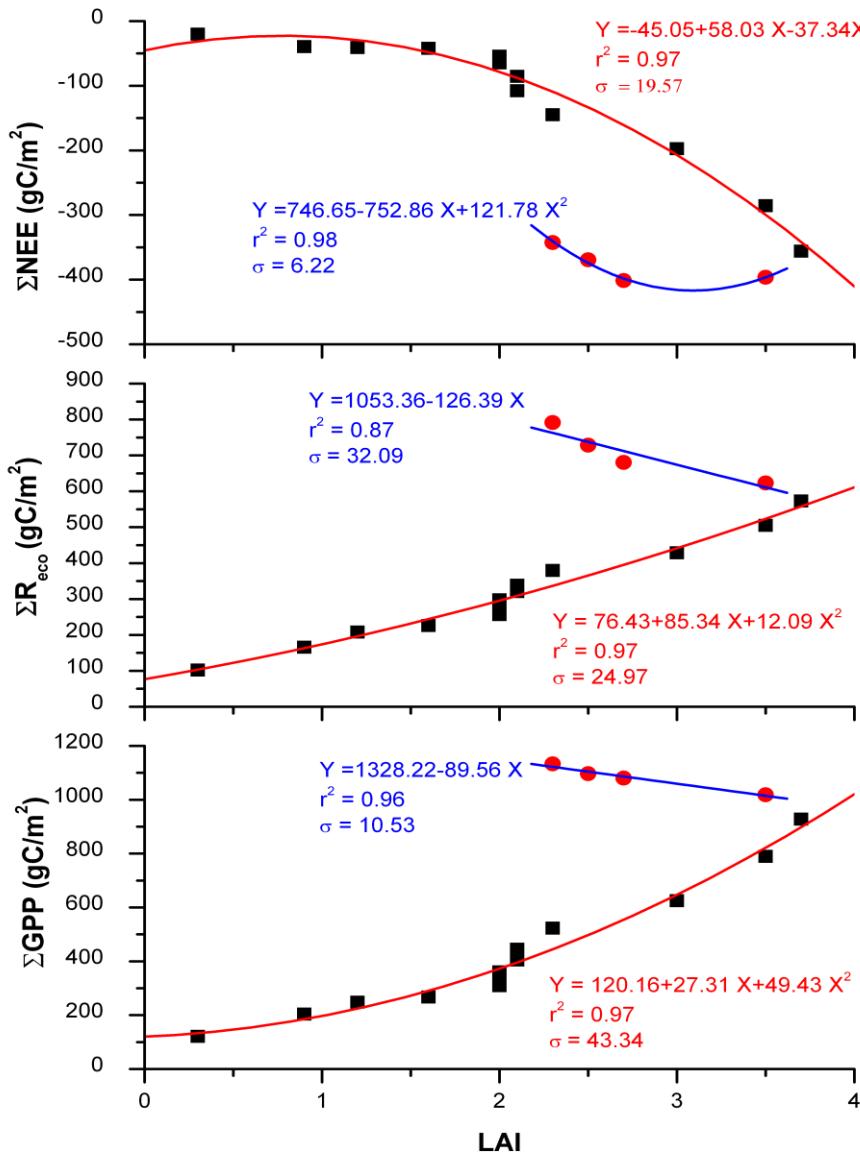
Gap filling and flux partitioning of EC data have been done according to the methods which are explained by Reichstein et al. (2005) and Falge (2001).



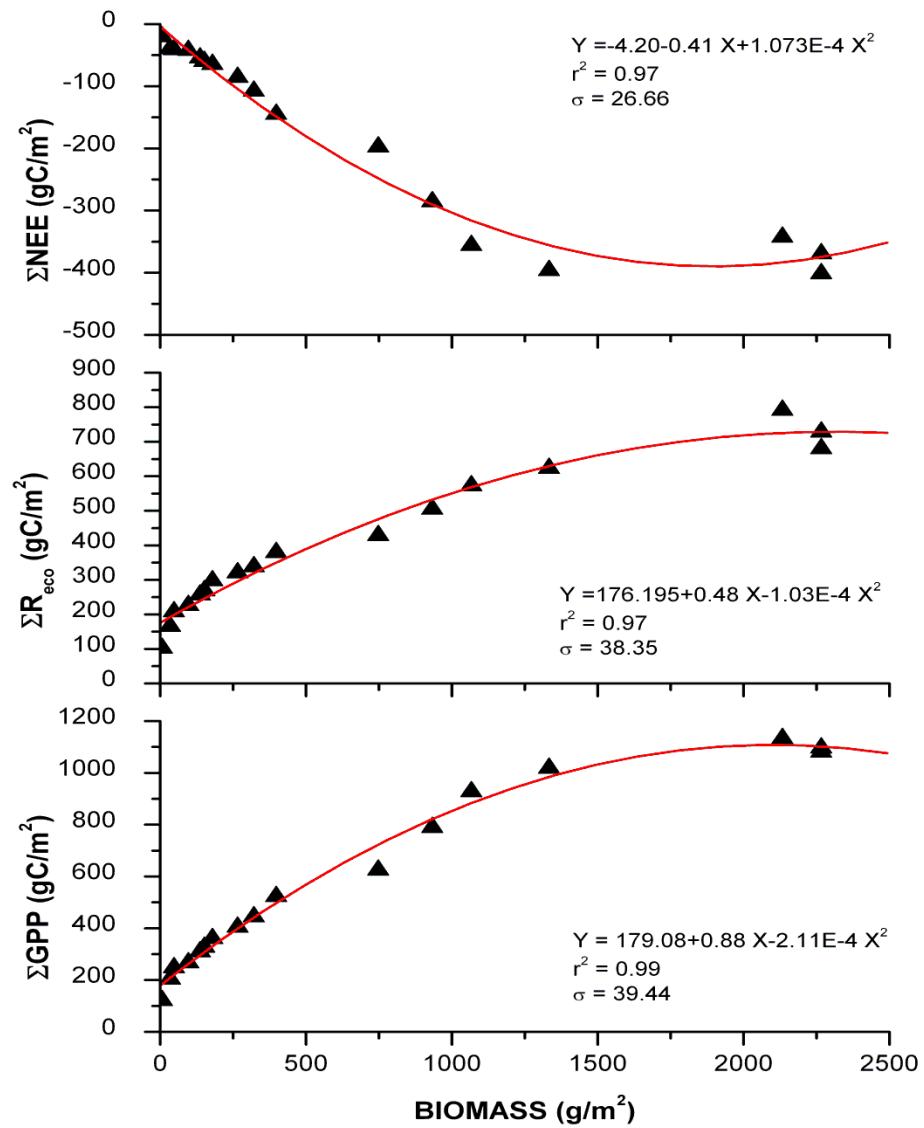
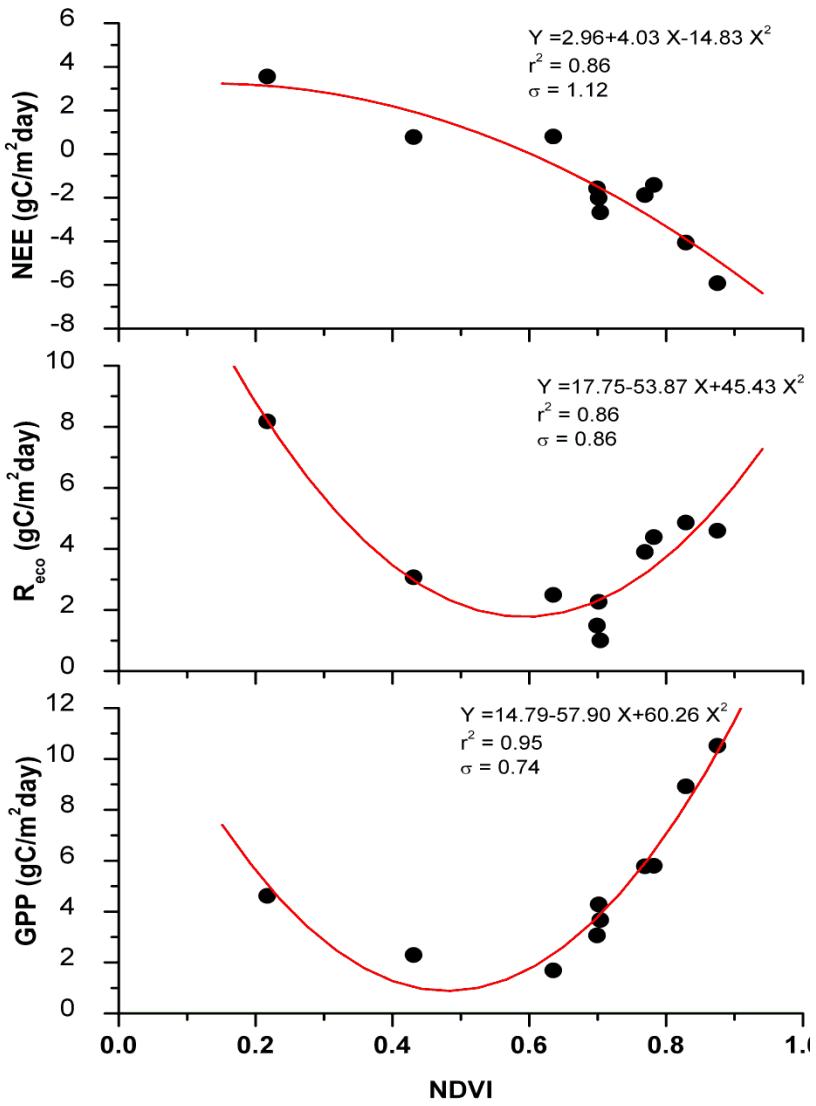
# RESULTS & DISCUSSION



# RESULTS&DISCUSSION



# RESULTS & DISCUSSION



# INTRODUCTION

- Determination of evapotranspiration (ET) is an important issue particularly for water management considering its role as part of the hydrological cycle associated with the losses. Especially in the countries like Turkey, where the economy is majorly based on agriculture, water management is a crucial application. For an accurate water management, possible losses should be determined.
- ET is not always measured in meteorological stations, usually calculated by the equations which take part in literature. In this study different approaches used to calculate ET were compared to the measured data which was collected by a micrometeorological method (Bowen Ratio Energy Balance) over maize crop surface for 2010-2011 growing seasons in Thrace Region which is located in the northwestern part of

# LITERATURE REVIEW

Some examples of the comparative studies using empirical equations in the literature are given below:

- Xu and Singh (2001) compared seven temperature-based ET equations using two climatic stations' data (Rawson Lake and Atikokan stations) in Canada. They found that Blaney–Ciddle and Hargreaves method results have the least error when compared to the observations
- Er-Raki et al. (2009) compared measured ET values over citrus orchard by eddy covariance measurements and calculated reference ET values obtained by FAO-56 approach.
- Kashyap and Panda (2001), obtained the reference ET results by using empirical equations and then developed the crop coefficients for potato crop in a sub-humid region.
- Kişi (2013), compared Penman- Monteith (PM), Copais, Turc, Hargreaves-Samani, Hargreves, Ritchie and Irmak methods to Valiantzas (2013) method using Adana, Antalya, Isparta and Mersin stations' data. The Copais equation performs the best out of the nine methods while the worst is Turc method.
- Srivastava et al. (2016) used empirical evapotranspiration methods

# STUDY AREA

- Experiment field covers 3.1 ha and is located in the research area of Atatürk Soil Water and Agricultural Meteorology Research Institute Directorate (ARID) (41° 41'53" N, 27° 12'37" E, 170 asl), in the Kırklareli



*Figure 1 - Experiment Field in  
Kırklareli, Turkey*

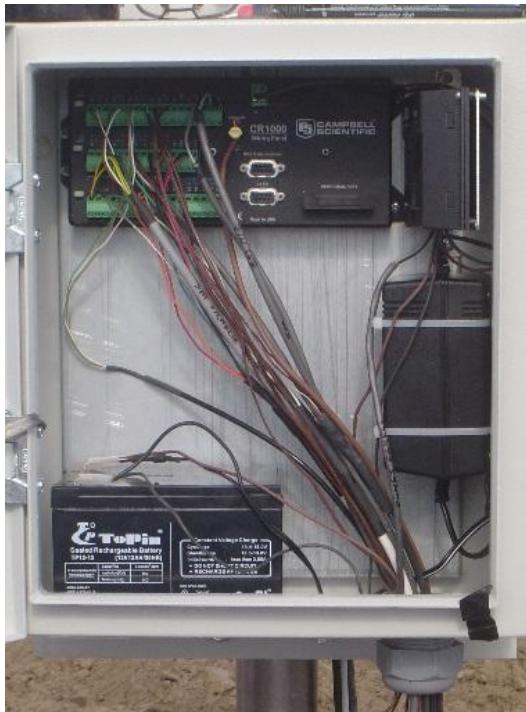
# DATA AND METHOD

- Bowen Ratio Energy Balance (BREB) method is used to determine ET in this study.
- Latent heat flux is computed from surface energy budget components and Bowen Ratio (ratio of sensible to latent heat fluxes) in this method (Burba&Anderson, 2010)
- Bowen Ratio Energy Balance (BREB):



**Figure 2 – BREB  
Measurement System**

# Components of the BREB system



# BREB



# **Materyal ve Metot**

## **Metot - Bowen Oranı Enerji Dengesi (BREB)**

### **Data analysis**

APRIL 1982

ATSUMU OHMURA

595

#### **Objective Criteria for Rejecting Data for Bowen Ratio Flux Calculations**

ATSUMU OHMURA

*Department of Geography, Swiss Federal Institute of Technology (ETH), CH-8092 Zürich, Switzerland*

(Manuscript received 9 April 1981, in final form 4 January 1982)



Agricultural and Forest Meteorology 97 (1999) 141–150

AGRICULTURAL  
AND  
FOREST  
METEOROLOGY

[www.elsevier.com/locate/agrformet](http://www.elsevier.com/locate/agrformet)

#### **Assessment of reliability of Bowen ratio method for partitioning fluxes**

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*Dpto. de Medio Ambiente y Ciencia del Suelo, E.T.S Ingeniería Agraria, Universidad de Lleida, Av. Rovira Roure, 177. E-25198-Lleida, Spain*

Received 8 September 1998; received in revised form 21 July 1999; accepted 28 July 1999

# **Materyal ve Metot**

## **Metot - Bowen Oranı Enerji Dengesi (BREB)**

### **Criteria**

Kullanılabilir Enerji	Buhar Basınç Farkı	Bowen Oranı	Isı Akıları
$R_n - G > 0$	$\Delta e_a > 0$	$\beta > -1$	$LE > 0$ ve $-1 < \beta \leq 0$ için $H \leq 0$
	$\Delta e_a > 0$	$\beta > -1$	$LE > 0$ ve $\beta > 0$ için $H > 0$
	$\Delta e_a < 0$	$\beta < -1$	$LE < 0$ ve $H > 0$
$R_n - G < 0$	$\Delta e_a > 0$	$\beta < -1$	$LE > 0$ ve $H < 0$
	$\Delta e_a < 0$	$\beta < -1$	$LE < 0$ ve $-1 < \beta \leq 0$ için $H \geq 0$
	$\Delta e_a < 0$	$\beta > -1$	$LE < 0$ ve $\beta > 0$ için $H < 0$

# DATA AND METHOD

- The ET measurements were taken over maize crop for 2010 and 2011 growing seasons.
- 2010 season from planting to harvesting covers the period between 27.04.2010-24.09.2010 while 2011 growing season is between 26.04.2011-23.09.2011 (totally 151 days for both two seasons)



*Figure 3 – Phenological*  
© 2013 M. A.

# DATA AND METHOD

- The BREB is expressed in the form by approximating the fluxes by the temperature and humidity gradient.
- Temperature gradient ( $\Delta T$ ) and specific humidity ( $\Delta q$ ) is the differences between different levels of air temperature and humidity measurements.
- In our study, measurements are at 2 m and 3 m level over surface area.
- Daily averaged data of temperature and humidity profile in the surface boundary layer for estimating surface energy fluxes and ET.
- BREB is used to determine  $K_c$ , water use (Malek & Bingham, 1993), and plant-water relation studies (Grantz & Meinzer, 1991) with continuous and high temporal scale (less than 1 h) data.
- In addition, this method does not require surface aerodynamic resistance information to estimate actual ET and apply different surface area (Todd et al., 2000).

# DATA AND METHOD

- For the comparisons, 18 different equations were used to calculate potential or reference ET.
- These equations are mainly based on meteorological variables like global solar radiation, maximum, minimum and mean air temperature, relative humidity, air pressure, vapor pressure, wind speed etc.



## EMPIRICAL EQUATIONS TO CALCULATE EVAPOTANSPIRATION

### Temperature-based equations:

- Schendel (1967):  
—

### Radiation-based equations:

- Turc (1961):  
—

RH  $\geq$  50

—

—

—

RH < 50

- Makkink (1957):  
— —

(—)

- McGuinness and Bordne (1972):  
—

— —

- Priestley Taylor (1972):  
— —

- Jones Ritchie (1972):  
—

- Jensen – Haise (1963):  
—

- Irmak (2003):  
—

- Hargreaves (1975):  
( )

### Mass transfer-based equations:

- Dalton (1802):  
( )

- Trabert (1896):  
 $\sqrt{ } ( )$

- Meyer (1945):  
( )

- Albrecht (1950):  
( )

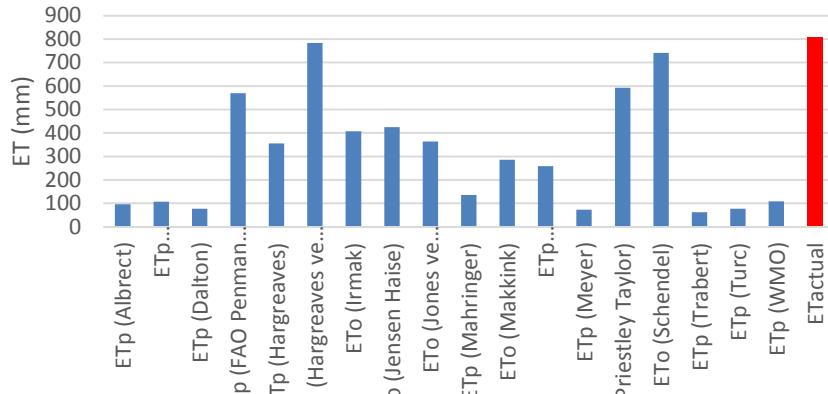
- Brockamp and Wenner (1963):  
( )

- WMO (1966):  
( )

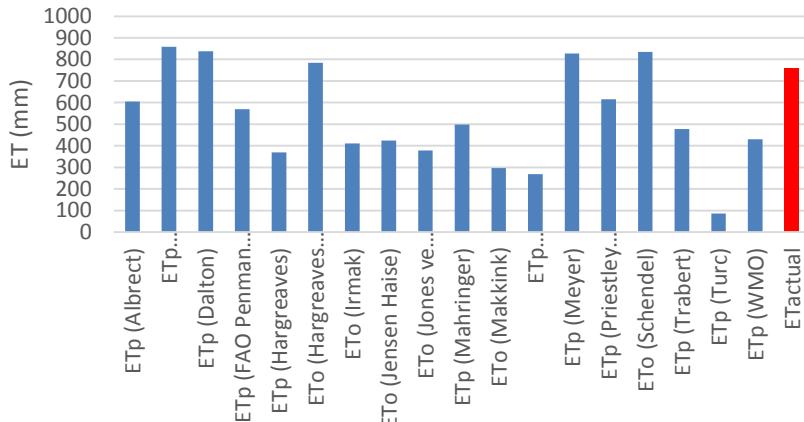
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# RESULTS

Maize Total ET Values for 2010 Growing Season

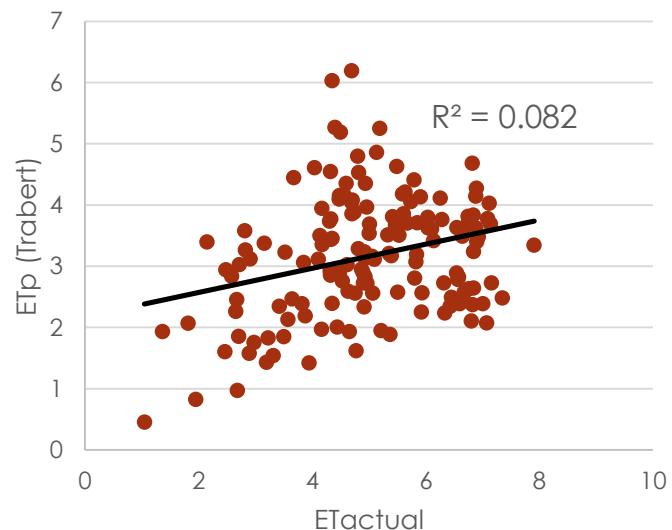
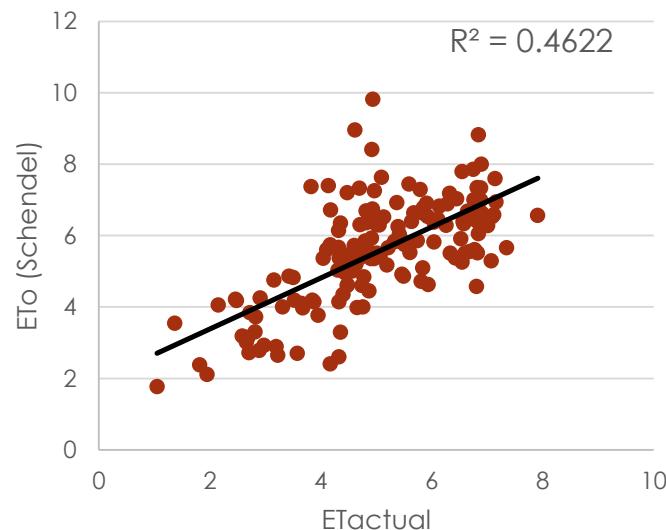
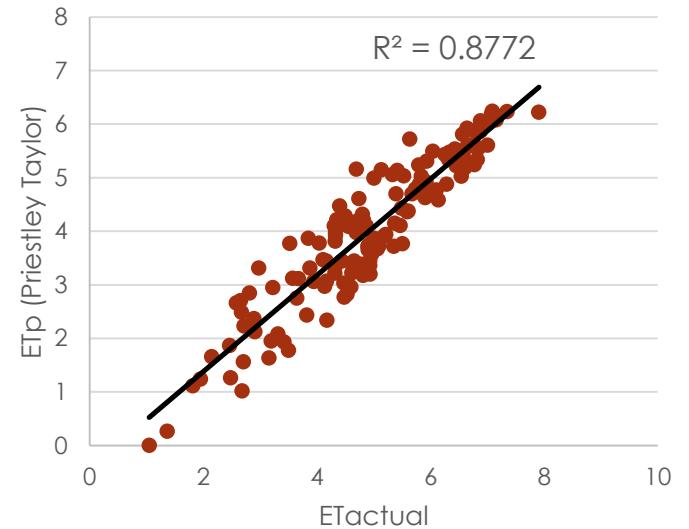
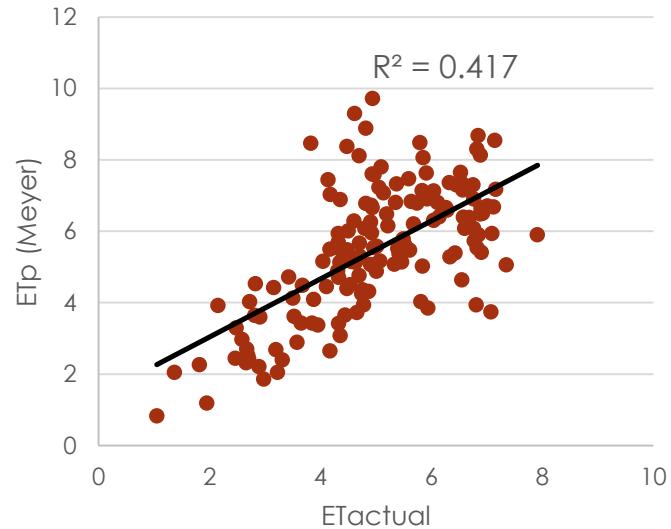


Maize Total ET Values for 2011 Growing Season



	2010 TOTAL ET (mm)	2011 TOTAL ET (mm)
ETp (Albrecht)	96	605
ETp (Brockamp&Wenner)	107	859
ETp (Dalton)	77	837
ETp (FAO Penman Monteith)	569	569
ETp (Hargreaves)	355	369
ETo (Hargreaves ve Samani)	784	784
ETo (Irmak)	407	411
ETo (Jensen Haise)	425	425
ETo (Jones ve Ritchie)	363	377
ETp (Mahringer)	136	499
ETo (Makkink)	285	296
ETp (McGuinness&Bordne)	259	268
ETp (Meyer)	73	828
ETp (Priestley Taylor)	592	616
ETo (Schendel)	741	835
ETp (Trabert)	62	477
ETp (Turc)	77	85
ETp (WMO)	109	430
ETactual	808	755

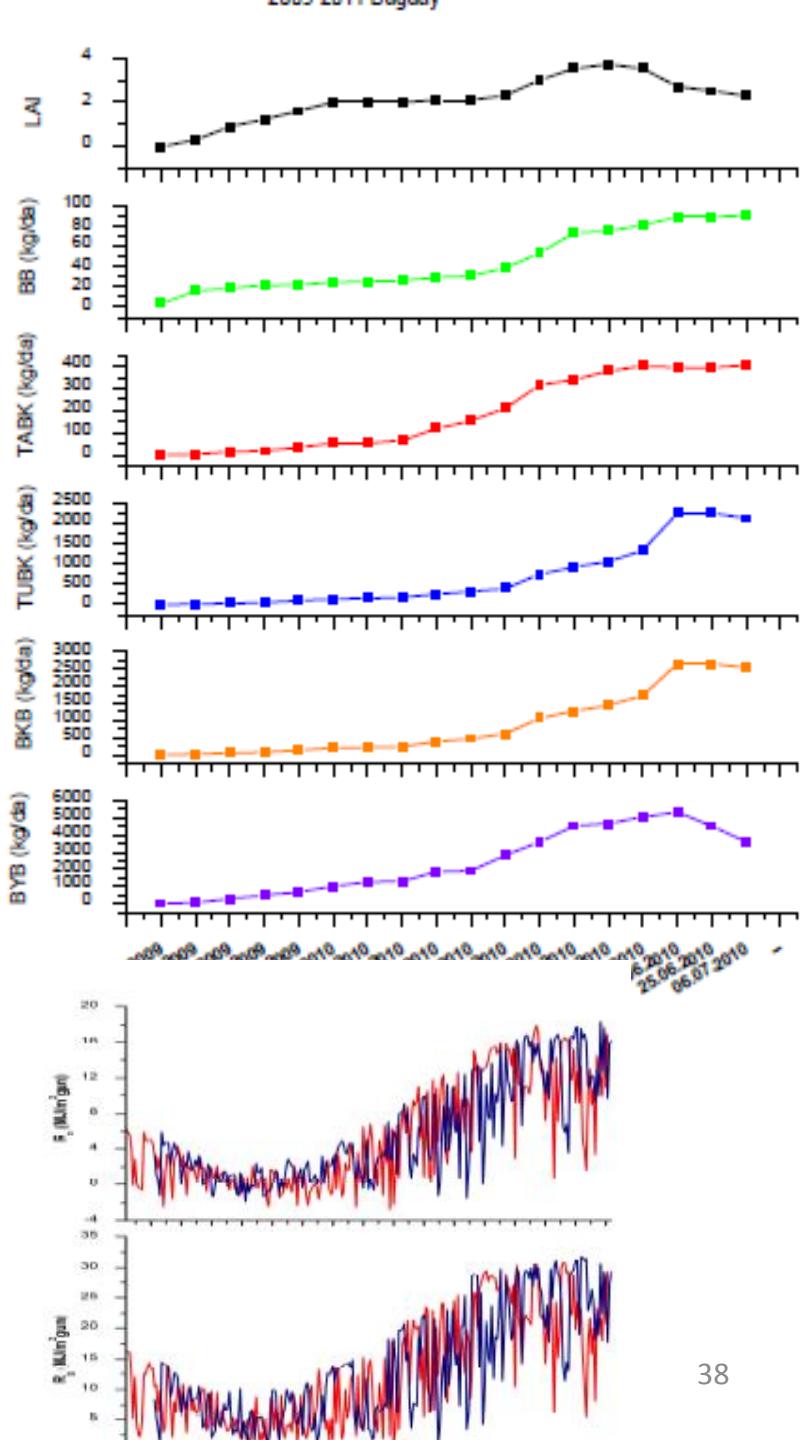
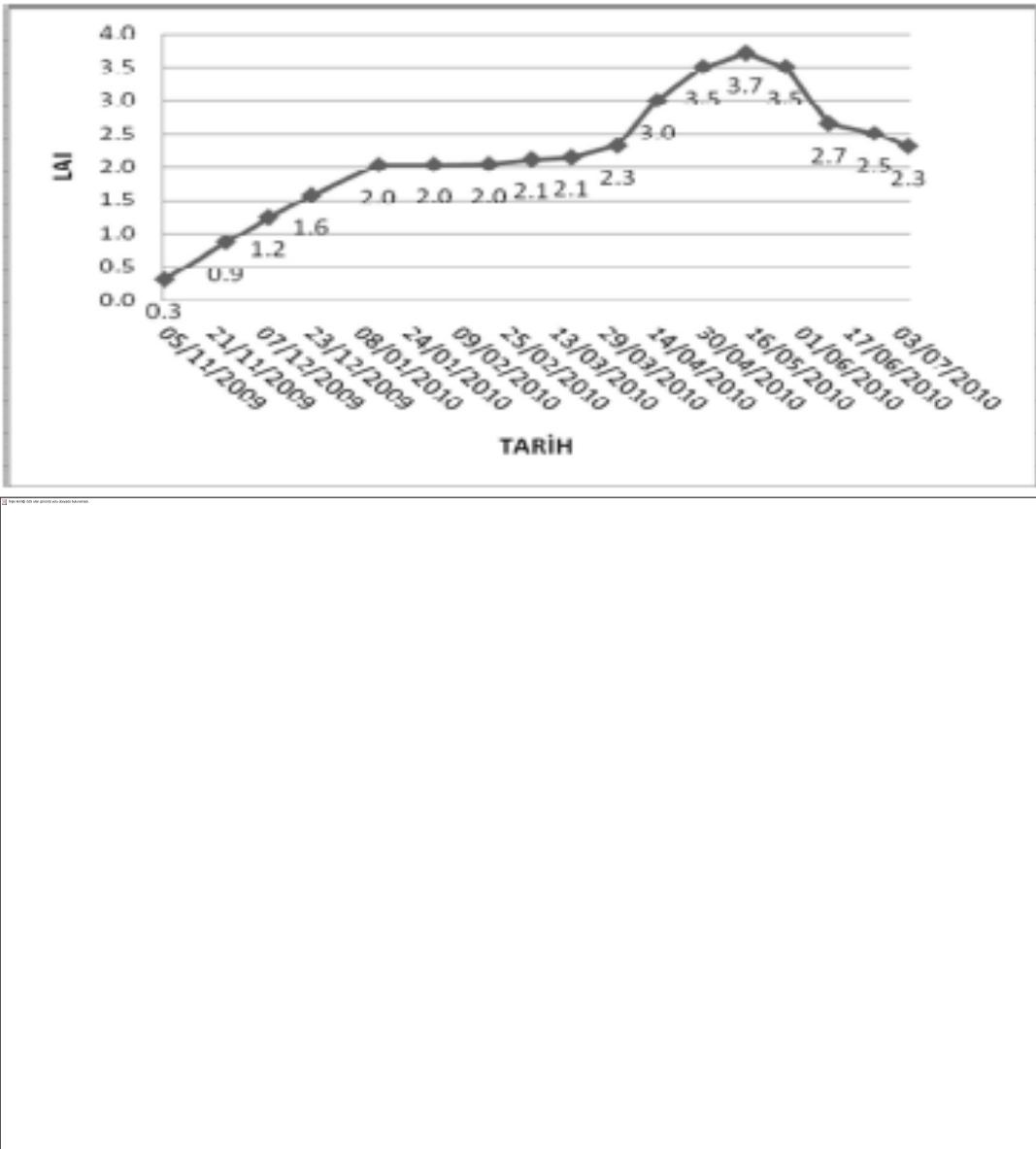
# RESULTS





# Agrometeorological measurements





# Experiments and Observations

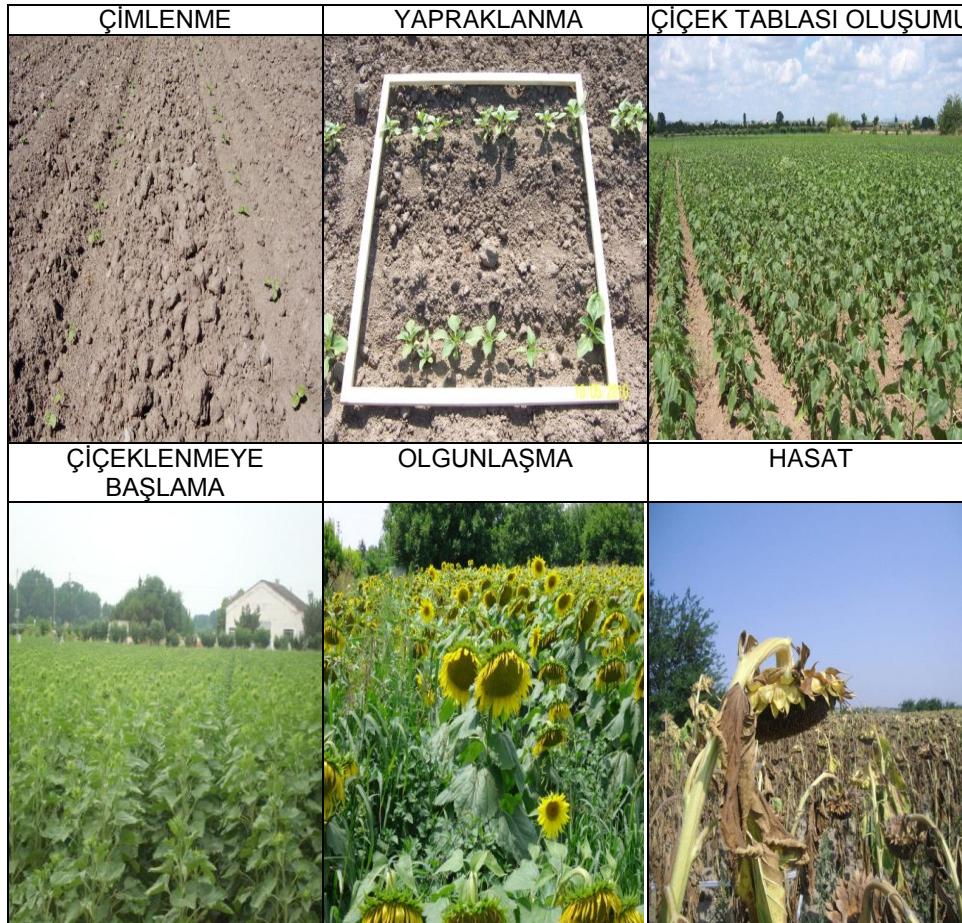


WINTER WHEAT PHENOLOGICAL OBSERVATIONS	DATE
Planting	09.10.2009
Germination	17.10.2009
2. Leaf	21.10.2009
3. Leaf	26.10.2009
Tillering	25.11.2009
Stem Formation	31.03.2010
Earing	26.04.2010
Flowering	10.05.2010
End of flowering	24.05.2010
Grain filling	24.05.2010
Maturity	04.06.2010
Harvest	06.07.2010

# Maize

ÇİMLENME	9. YAPRAK	KOÇAN OLUŞUMU
		
TEPE PÜSKÜLÜ ÇIKARMA	OLGUNLAŞMA	HASAT
		

# Sunflower



# Measurements



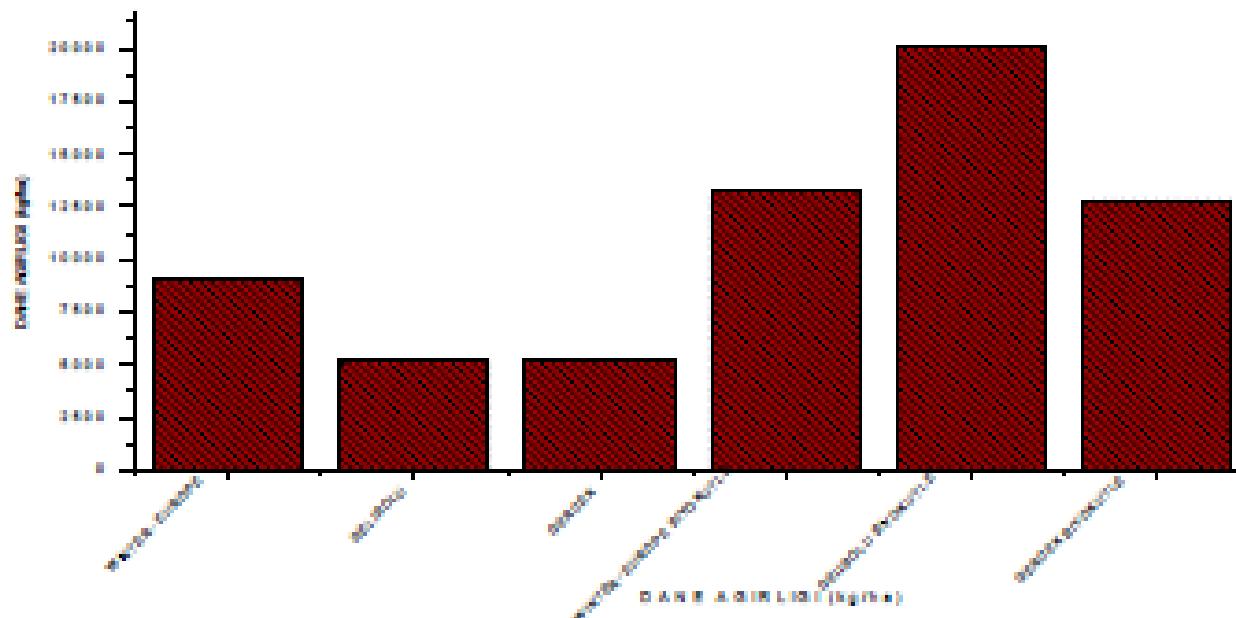
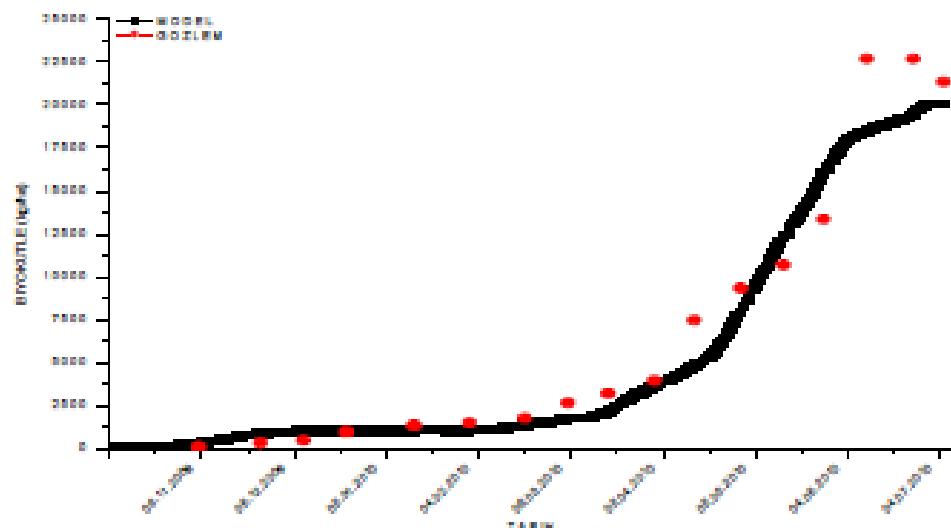




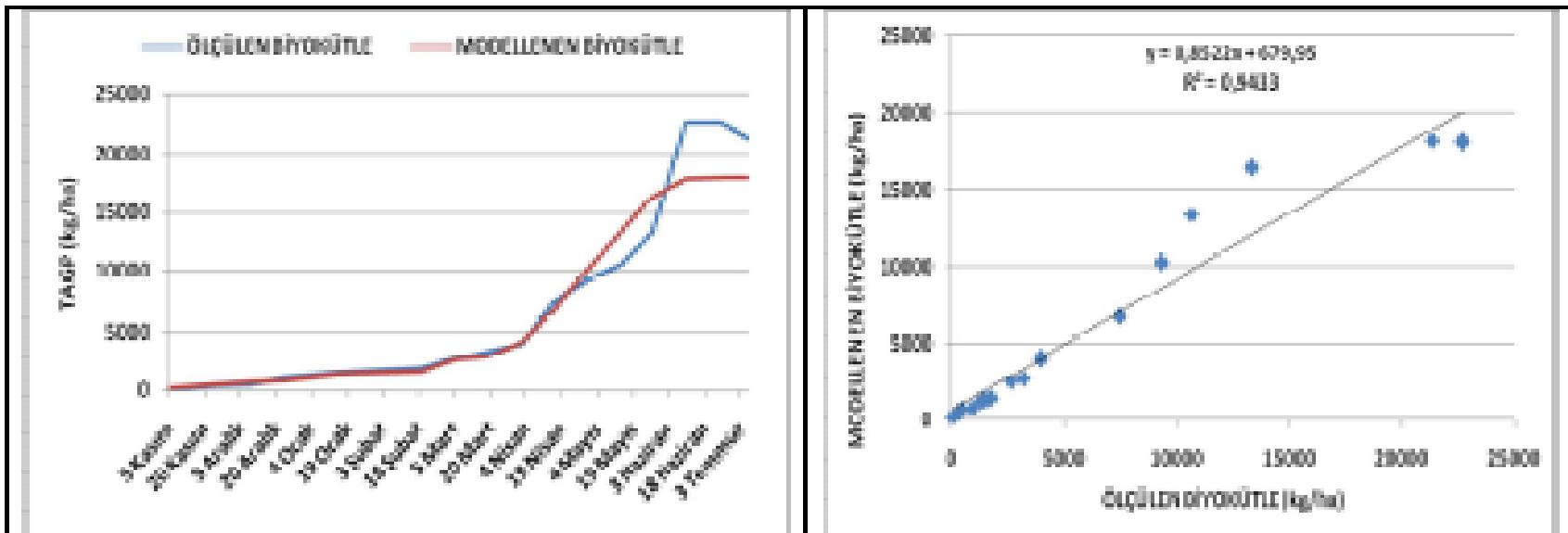


LAI

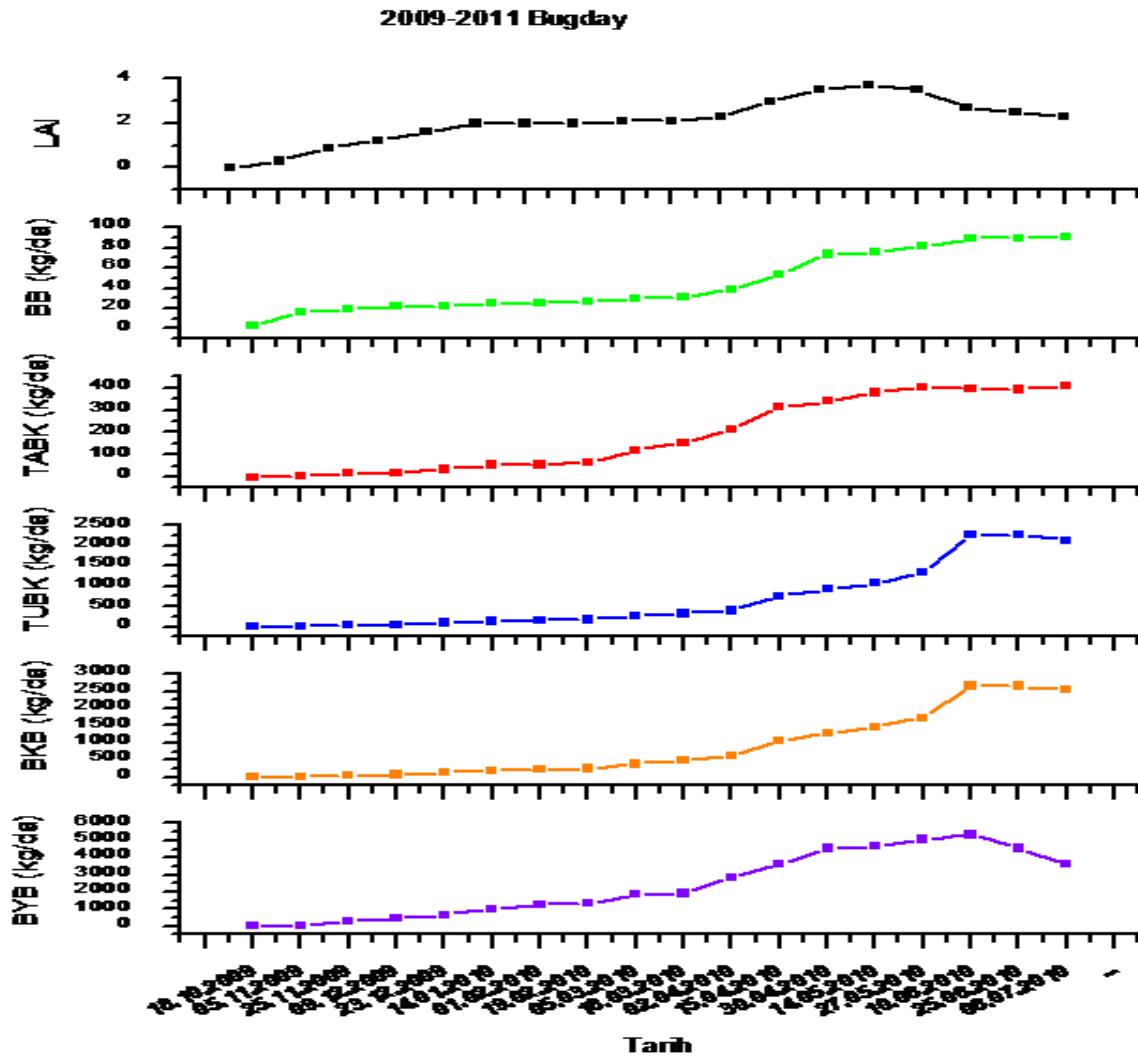
# Models Validation



# Modelled – Measured

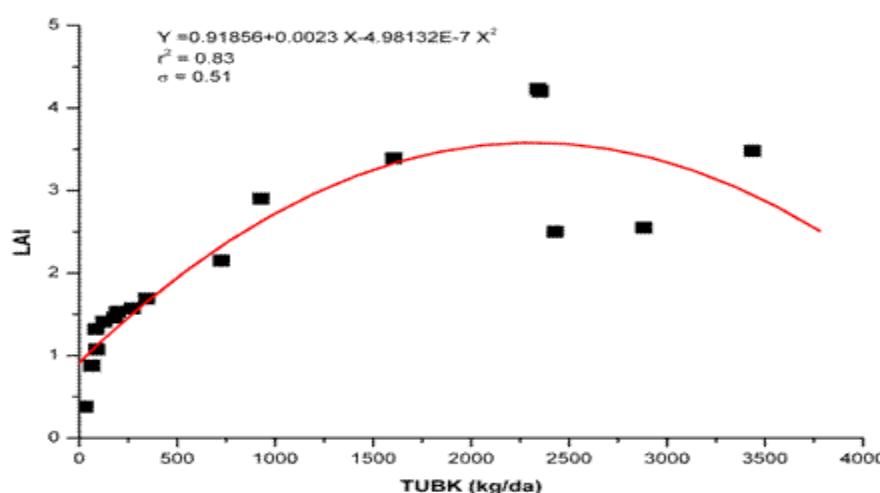
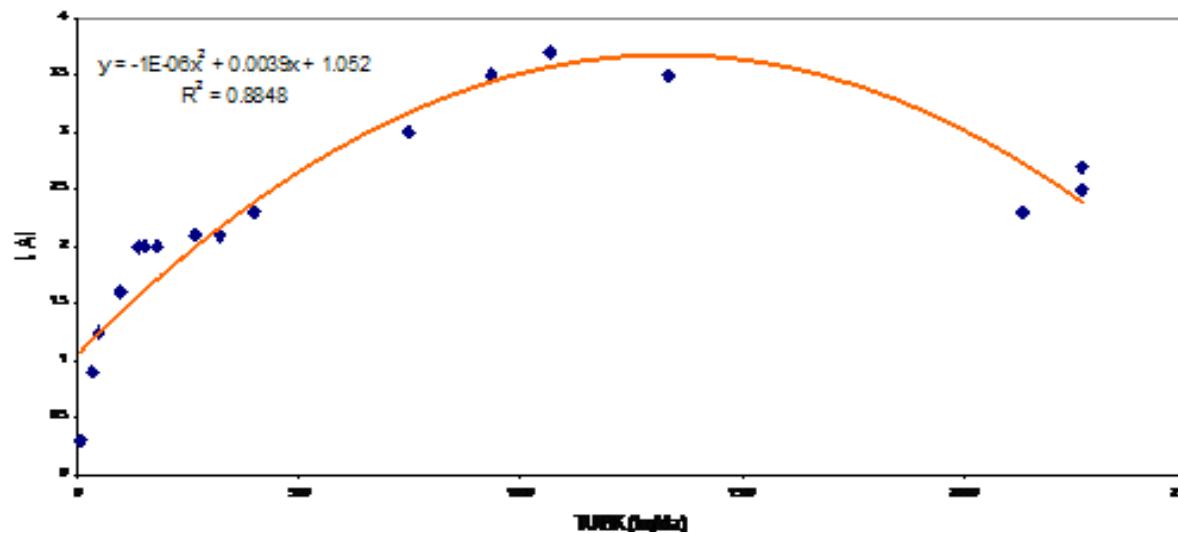


# Biomass



# Biomass-LAI

2009-2010 Bagley

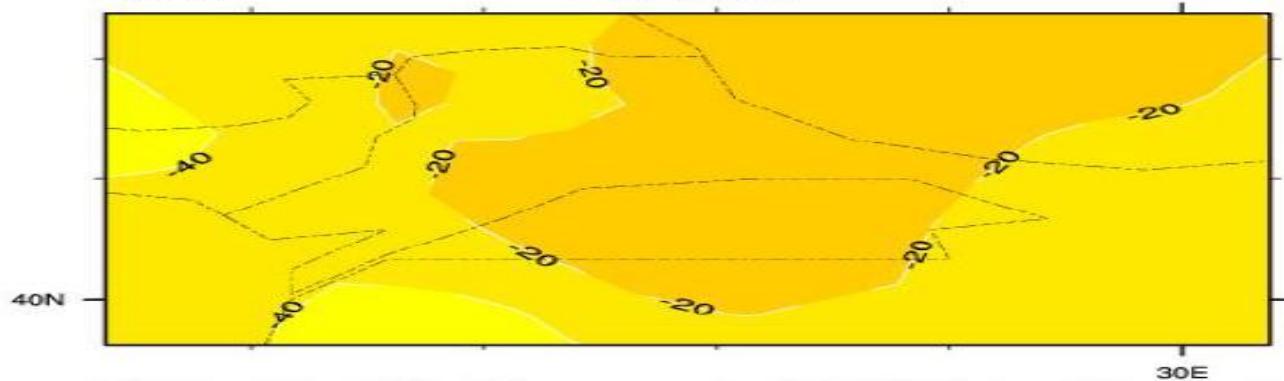


## Turkey (future):

Total Annual Precipitation Difference according to KNMI(r2) Regional Climate Model

Precipitation

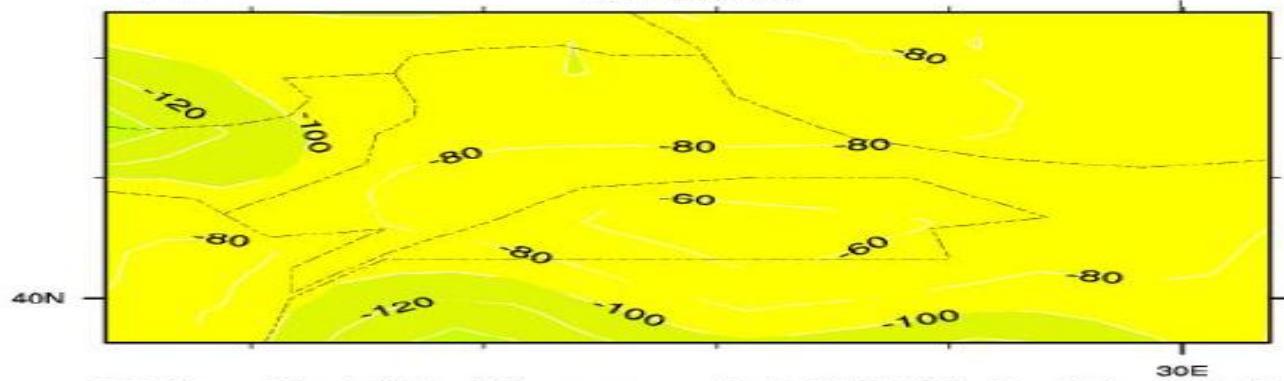
2011-2040 1971-2000



Total Annual Precipitation Difference according to KNMI(r2) Regional Climate Model

Precipitation

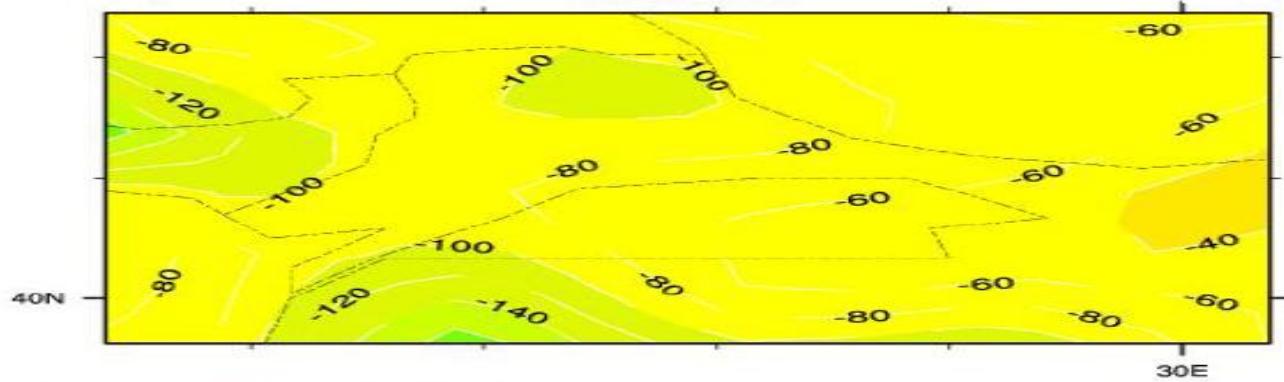
2041-2070 1971-2000



Total Annual Precipitation Difference according to KNMI(r2) Regional Climate Model

Precipitation

2071-2100 1971-2000



# Thrace/Turkey (future):

MİN. SICAKLIK (°C)	1975-2010				2011-2040				2041-2070				2071-2100			
	TÜM YIL	BUĞDAY	AYÇİCEĞİ	MISIR	TÜM YIL	BUĞDAY	AYÇİCEĞİ	MISIR	TÜM YIL	BUĞDAY	AYÇİCEĞİ	MISIR	TÜM YIL	BUĞDAY	AYÇİCEĞİ	MISIR
MINIMUM	-2.34	-2.34	5.02	7.72	-1.28	-1.28	6.84	8.60	0.17	0.17	6.91	10.13	1.02	1.02	8.92	11.99
ORTALAMA	8.20	5.76	13.90	14.67	9.30	6.87	15.14	15.93	10.65	8.10	16.85	17.72	11.79	9.23	17.86	18.65
MAKSİMUM	18.89	17.60	18.89	18.89	20.13	19.20	20.13	20.13	22.04	20.95	22.04	22.04	22.17	22.17	22.17	22.17
STD. SAPMA	6.38	5.64	3.88	3.17	6.53	5.85	3.86	3.16	6.88	6.19	4.20	3.42	6.79	6.08	4.05	3.35

MAK. SICAKLIK (°C)	1975-2010				2011-2040				2041-2070				2071-2100			
	TÜM YIL	BUĞDAY	AYÇİCEĞİ	MISIR	TÜM YIL	BUĞDAY	AYÇİCEĞİ	MISIR	TÜM YIL	BUĞDAY	AYÇİCEĞİ	MISIR	TÜM YIL	BUĞDAY	AYÇİCEĞİ	MISIR
MINIMUM	5.65	5.65	16.59	18.53	6.01	6.01	18.00	20.44	7.96	7.96	18.52	21.44	8.75	8.75	19.76	23.24
ORTALAMA	18.20	15.20	26.49	27.42	19.43	16.43	27.92	28.89	20.99	17.87	29.96	31.07	22.07	18.99	30.79	31.84
MAKSİMUM	32.38	30.78	32.38	32.38	33.96	33.00	33.96	33.96	36.50	35.01	36.50	36.50	35.95	35.92	35.95	35.95
STD. SAPMA	8.67	7.99	4.52	3.64	8.89	8.28	4.44	3.65	9.32	8.71	4.87	3.91	9.15	8.52	4.75	3.83

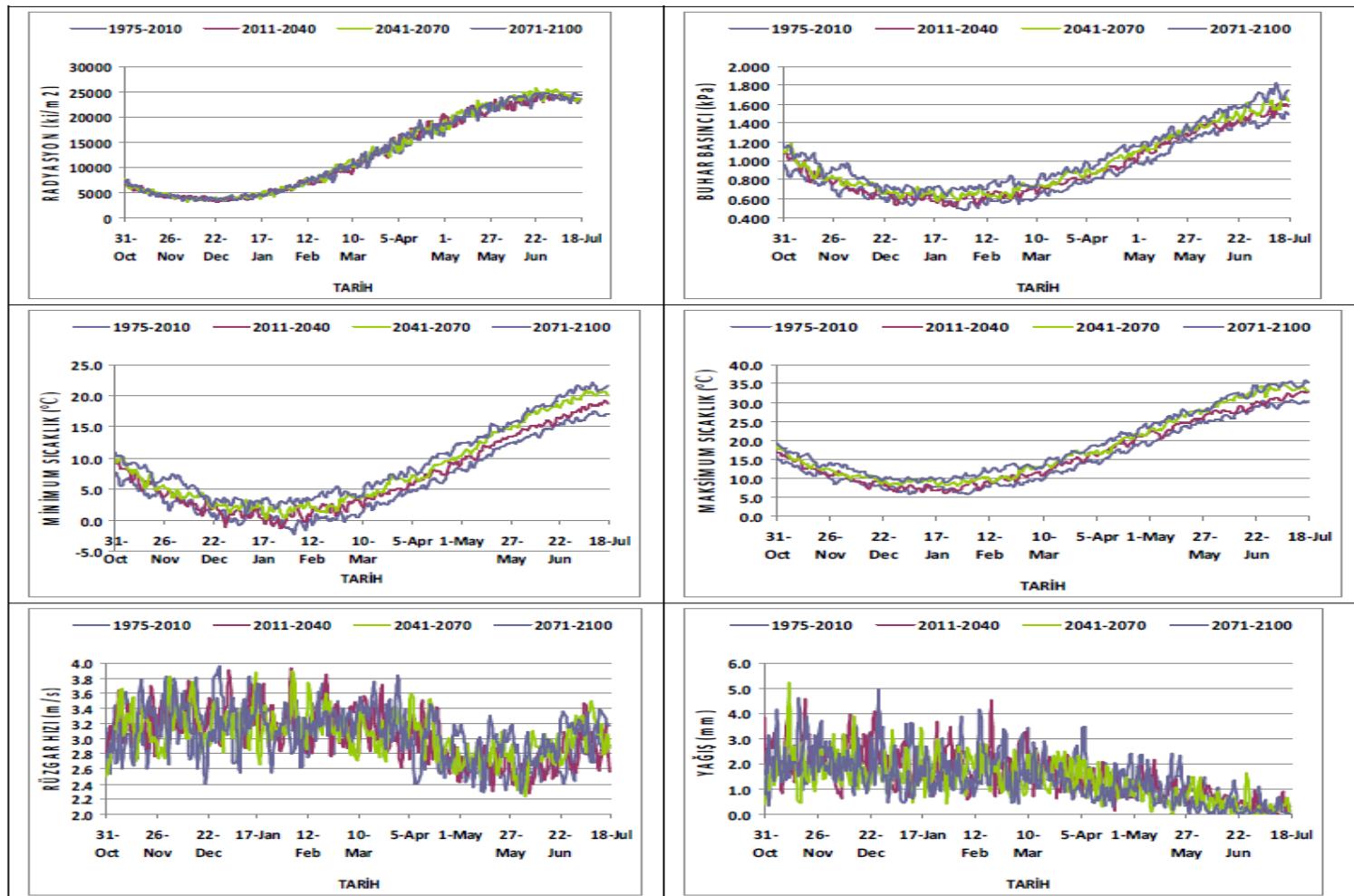
  

RADYASYON(MJ/m <sup>2</sup> )	1975-2010				2011-2040				2041-2070				2071-2100			
	TÜM YIL	BUĞDAY	AYÇİCEĞİ	MISIR	TÜM YIL	BUĞDAY	AYÇİCEĞİ	MISIR	TÜM YIL	BUĞDAY	AYÇİCEĞİ	MISIR	TÜM YIL	BUĞDAY	AYÇİCEĞİ	MISIR
MINIMUM	3.283	3.283	15.217	16.029	3.104	3.104	15.617	17.916	3.147	3.147	16.178	17.158	3.186	3.186	15.705	18.084
ORTALAMA	13.267	12.121	21.037	21.808	13.467	12.317	21.305	22.114	13.691	12.566	21.754	22.597	13.641	12.519	21.583	22.396
MAKSİMUM	24.714	24.714	24.714	24.714	24.404	24.404	24.404	24.404	25.645	25.645	25.645	25.645	24.794	24.794	24.794	24.794
STD. SAPMA	7.175	7.508	2.387	1.833	7.276	7.632	2.266	1.617	7.435	7.846	2.466	1.859	7.377	7.766	2.404	1.808

YAĞIŞ(mm)	1975-2010				2011-2040				2041-2070				2071-2100			
	TÜM YIL	BUĞDAY	AYÇİCEĞİ	MISIR	TÜM YIL	BUĞDAY	AYÇİCEĞİ	MISIR	TÜM YIL	BUĞDAY	AYÇİCEĞİ	MISIR	TÜM YIL	BUĞDAY	AYÇİCEĞİ	MISIR
MINIMUM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ORTALAMA	1.3	1.6	0.7	0.6	1.3	1.5	0.6	0.5	1.1	1.3	0.4	0.4	1.1	1.3	0.4	0.3
MAKSİMUM	4.9	4.9	2.4	2.4	4.6	4.6	2.2	2.2	5.2	5.2	2.1	1.8	4.3	4.3	2.2	2.2
STD. SAPMA	0.9	0.9	0.6	0.6	1.0	1.0	0.5	0.5	0.9	0.8	0.5	0.4	0.9	0.9	0.5	0.4
TOPLAM	486.9	413.1	99.4	74.5	461.6	397.5	83.2	61.5	389.9	340.4	63.5	45.3	383.5	331.3	56.7	40.1

# Thrace/Turkey (future): Variations Within Growing Periods



Şekil 5.9: Meteorolojik değişkenlerin 1975'ten 2100'e kadar değişimi (Kırklareli-Buğday gelişme dönemi).

# Sensitivity Analysis

Kırklareli ilinin ikliminin buğday verimine hassasiyetinin CERES-Wheat Modeli ile belirlenmesi.

Değişim (%)	Duyarlılık Analizi ve Senaryolar																			
	T	T+1	T+2	T+3	T+4	T+5	T-1	P	P-%10	P-%20	P-%30	P-%40	Rg	Rg+%10	Rg+%20	Rg+%30	CO2	CO2x1.5	CO2x2	CO2x3
T	0,0	-7,1	-10,7	-19,2	-28,8	-35,9	6,9	0,0	1,2	-0,6	0,8	-9,7	0,0	7,2	9,8	16,1	0,0	9,3	17,8	27,6
T+1	-7,1	-7,1	0,0	0,0	0,0	0,0	0,0	-7,1	-6,7	-5,9	-4,7	-4,2	-7,1	-3,0	1,1	4,6	-7,1	-0,6	5,0	11,6
T+2	-10,7	0,0	-10,7	0,0	0,0	0,0	0,0	-10,7	-8,9	-8,3	-7,3	-6,9	-10,7	-4,4	-0,3	2,8	-10,7	-5,3	-1,3	2,9
T+3	-19,2	0,0	0,0	-19,2	0,0	0,0	0,0	-19,2	-18,6	-18,0	-17,2	-16,8	-19,2	-13,5	-8,3	-3,9	-19,2	-11,8	-5,7	0,2
T+4	-28,8	0,0	0,0	0,0	-28,8	0,0	0,0	-28,8	-28,2	-27,5	-26,8	-26,5	-28,8	-25,2	-21,8	-19,3	-28,8	-23,9	-20,2	-16,7
T+5	-35,9	0,0	0,0	0,0	0,0	-35,9	0,0	-35,9	-35,4	-34,7	-34,0	-33,8	-35,9	-33,1	-31,5	-30,4	-35,9	-32,7	-30,6	-29,0
T-1	6,9	0,0	0,0	0,0	0,0	0,0	6,9	6,9	8,1	8,3	6,9	-16,4	6,9	13,1	20,3	21,3	6,9	15,4	23,1	31,0
P	0,0	-7,1	-10,7	-19,2	-28,8	-35,9	6,9	0,0	1,2	-0,6	0,8	-9,7	0,0	7,2	9,8	16,1	0,0	9,3	17,8	27,6
P-%10	1,2	-6,7	-8,9	-18,6	-28,2	-35,4	8,1	1,2	1,2	0,0	0,0	0,0	1,2	4,7	10,6	16,7	1,2	10,4	18,9	28,6
P-%20	-0,6	-5,9	-8,3	-18,0	-27,5	-34,7	8,3	-0,6	0,0	-0,6	0,0	0,0	-0,6	5,6	8,6	-1,5	-0,6	7,4	14,7	23,3
P-%30	0,8	-4,7	-7,3	-17,2	-26,8	-34,0	6,9	0,8	0,0	0,0	0,8	0,0	0,8	-0,5	-12,0	-25,0	0,8	8,4	15,6	24,1
P-%40	-9,7	-4,2	-6,9	-16,8	-26,5	-33,8	-16,4	-9,7	0,0	0,0	0,0	-9,7	-9,7	-21,9	-34,6	-40,7	-9,7	7,0	16,7	25,2
Rg	0,0	-7,1	-10,7	-19,2	-28,8	-35,9	6,9	0,0	1,2	-0,6	0,8	-9,7	0,0	7,2	9,8	16,1	0,0	9,3	17,8	27,6
Rg+%10	7,2	-3,0	-4,4	-13,5	-25,2	-33,1	13,1	7,2	4,7	5,6	-0,5	-21,9	7,2	7,2	0,0	0,0	7,2	17,3	26,7	36,8
Rg+%20	9,8	1,1	-0,3	-8,3	-21,8	-31,5	20,3	9,8	10,6	8,6	-12,0	-34,6	9,8	0,0	9,8	0,0	9,8	19,3	27,9	37,5
Rg+%30	16,1	4,6	2,8	-3,9	-19,3	-30,4	21,3	16,1	16,7	-1,5	-25,0	-40,7	16,1	0,0	0,0	16,1	16,1	26,3	35,5	45,8
CO2	0,0	-7,1	-10,7	-19,2	-28,8	-35,9	6,9	0,0	1,2	-0,6	0,8	-9,7	0,0	7,2	9,8	16,1	0,0	9,3	17,8	27,6
CO2x1.5	9,3	-0,6	-5,3	-11,8	-23,9	-32,7	15,4	9,3	10,4	7,4	8,4	7,0	9,3	17,3	19,3	26,3	9,3	9,3	0,0	0,0
CO2x2	17,8	5,0	-1,3	-5,7	-20,2	-30,6	23,1	17,8	18,9	14,7	15,6	16,7	17,8	26,7	27,9	35,5	17,8	0,0	17,8	0,0
CO2x3	27,6	11,6	2,9	0,2	-16,7	-29,0	31,0	27,6	28,6	23,3	24,1	25,2	27,6	36,8	37,5	45,8	27,6	0,0	0,0	27,6

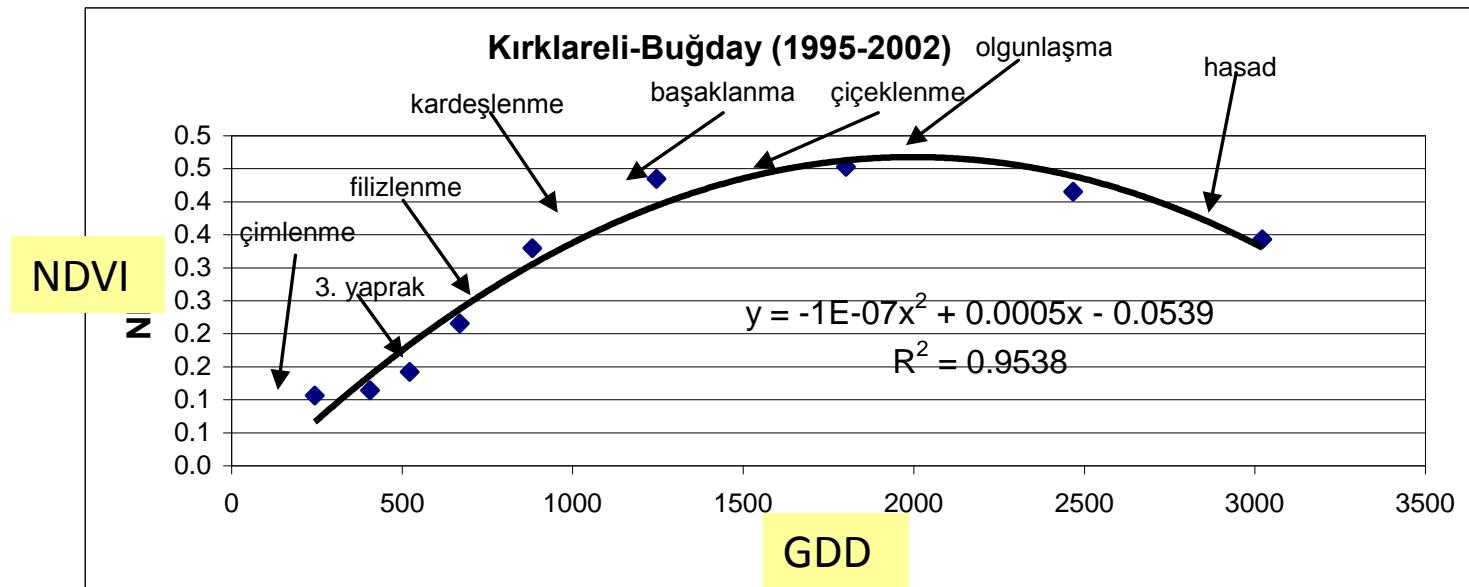
# Yields of Wheat, Sunflower, Mais (in Kırklareli) (Genetic coefficients based on database of 2010-2011

Kırklareli’nde Buğday (Gelibolu); Mısır (Helen) ve Ayçiçeği (Tunca) bitkilerinin (2010-2011 gelişme dönemi katsayılarına göre) dane veriminin iklim değişikliğinden etkilenme derecesi

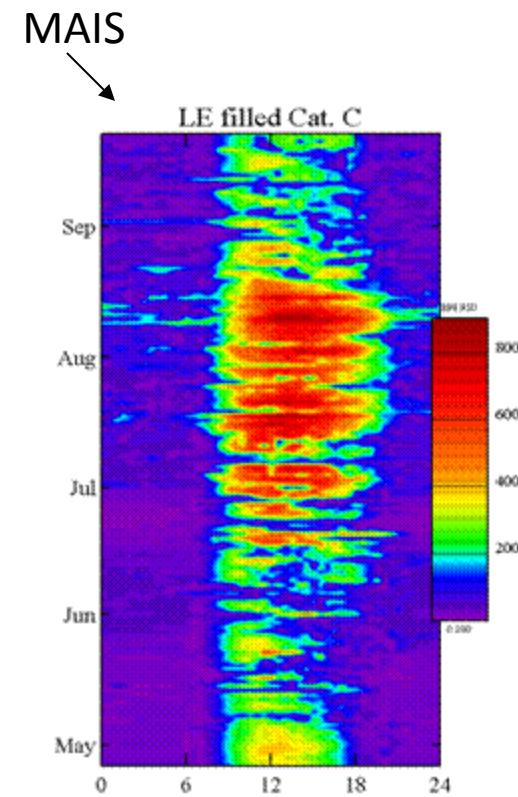
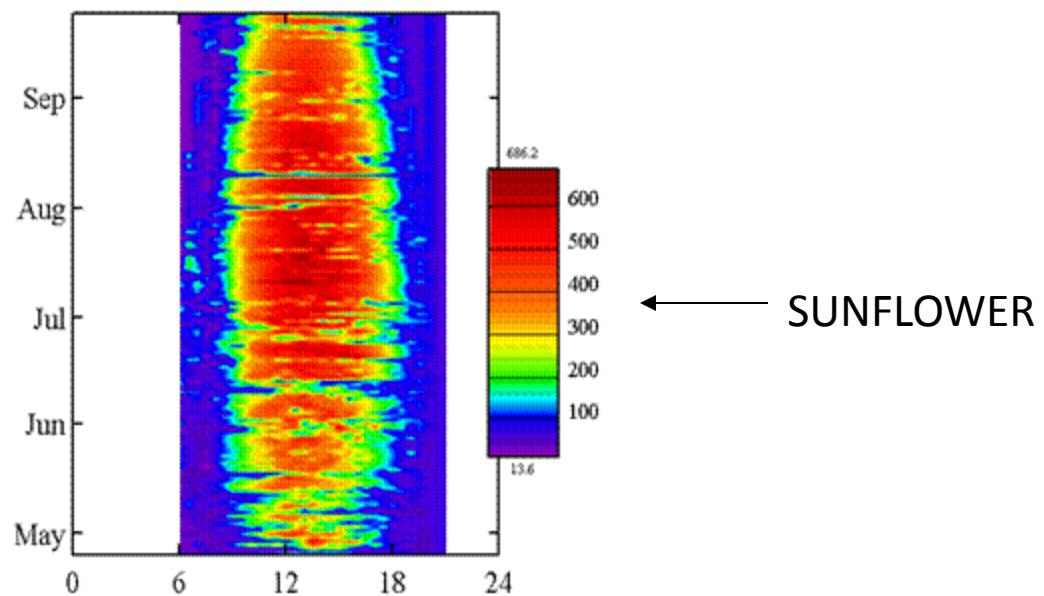
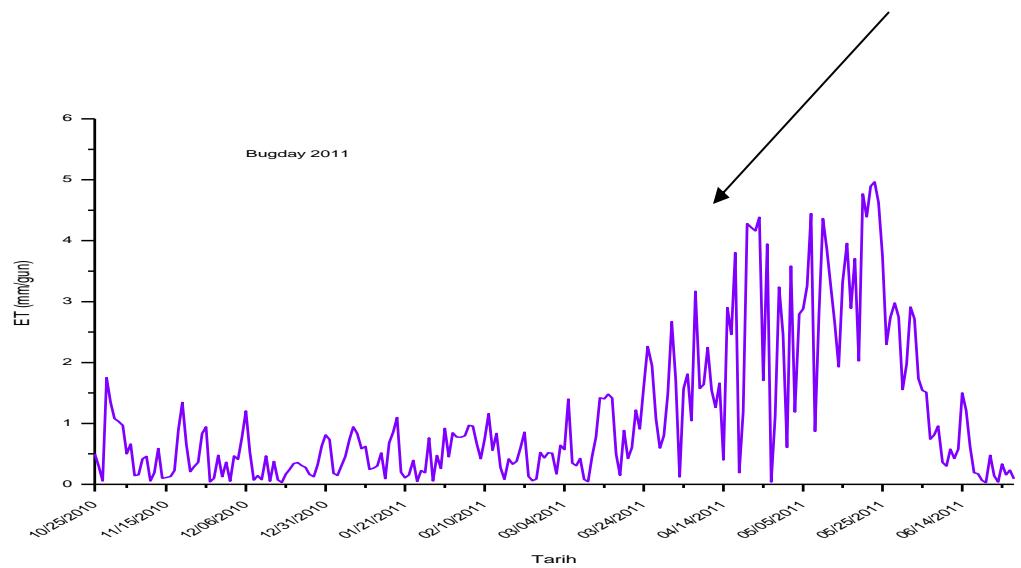
DANE	WOFOST					DSSAT				
<u>BITKİ</u>	2013-2040					2013-2040				
	<u>ORTALAMA</u>	<u>EN KURAK</u>	<u>EN YAĞIŞLI</u>	<u>EN SOĞUK</u>	<u>EN SICAK</u>	<u>ORTALAMA</u>	<u>EN KURAK</u>	<u>EN YAĞIŞLI</u>	<u>EN SOĞUK</u>	<u>EN SICAK</u>
BUĞDAY	%80 AZALIŞ	%97 AZALIŞ	%26 AZALIŞ	%11 ARTIŞ	%21 ARTIŞ	%8 AZALIŞ	%23 AZALIŞ	%37 AZALIŞ	%1 AZALIŞ	%35 AZALIŞ
AYÇİÇEĞİ	%41 AZALIŞ	%62 AZALIŞ	%16 ARTİŞ	%8 AZALIŞ	%62 AZALIŞ	%4 AZALIŞ	%7 AZALIŞ	SABİT	%6 ARTİŞ	%7 AZALIŞ
MISIR	%57 AZALIŞ	%46 AZALIŞ	%35 AZALIŞ	%44 AZALIŞ	%44 AZALIŞ	%13 AZALIŞ	%10 AZALIŞ	%10 AZALIŞ	%11 AZALIŞ	%12 AZALIŞ
<u>BITKİ</u>	2041-2070					2041-2070				
	<u>ORTALAMA</u>	<u>EN KURAK</u>	<u>EN YAĞIŞLI</u>	<u>EN SOĞUK</u>	<u>EN SICAK</u>	<u>ORTALAMA</u>	<u>EN KURAK</u>	<u>EN YAĞIŞLI</u>	<u>EN SOĞUK</u>	<u>EN SICAK</u>
BUĞDAY	%69 AZALIŞ	%13 ARTİŞ	%28 ARTİŞ	%10 AZALIŞ	%13 ARTİŞ	%12 AZALIŞ	%64 AZALIŞ	%47 AZALIŞ	%5 AZALIŞ	%64 AZALIŞ
AYÇİÇEĞİ	%59 AZALIŞ	%79 AZALIŞ	%16 AZALIŞ	%18 AZALIŞ	%79 AZALIŞ	%2 ARTİŞ	%36 AZALIŞ	%6 AZALIŞ	%8 ARTİŞ	%36 AZALIŞ
MISIR	%60 AZALIŞ	%62 AZALIŞ	%22 ARTİŞ	%16 AZALIŞ	%58 AZALIŞ	%15 AZALIŞ	%13 AZALIŞ	%16 AZALIŞ	%2 AZALIŞ	%25 AZALIŞ
<u>BITKİ</u>	2071-2100					2071-2100				
	<u>ORTALAMA</u>	<u>EN KURAK</u>	<u>EN YAĞIŞLI</u>	<u>EN SOĞUK</u>	<u>EN SICAK</u>	<u>ORTALAMA</u>	<u>EN KURAK</u>	<u>EN YAĞIŞLI</u>	<u>EN SOĞUK</u>	<u>EN SICAK</u>
BUĞDAY	%17 AZALIŞ	%90 AZALIŞ	%33 ARTİŞ	%33 ARTİŞ	%23 AZALIŞ	%20 AZALIŞ	%14 AZALIŞ	%30 AZALIŞ	%30 AZALIŞ	%45 AZALIŞ
AYÇİÇEĞİ	%63 AZALIŞ	%90 AZALIŞ	%47 AZALIŞ	%33 AZALIŞ	%90 AZALIŞ	%2 AZALIŞ	%10 AZALIŞ	%1 AZALIŞ	SABİT	%10 AZALIŞ
MISIR	%58 AZALIŞ	%53 AZALIŞ	%3 AZALIŞ	%27 AZALIŞ	%64 AZALIŞ	%17 AZALIŞ	%16 AZALIŞ	%3 AZALIŞ	%6 AZALIŞ	%16 AZALIŞ

Azalış=Decrease; Artış=Increase

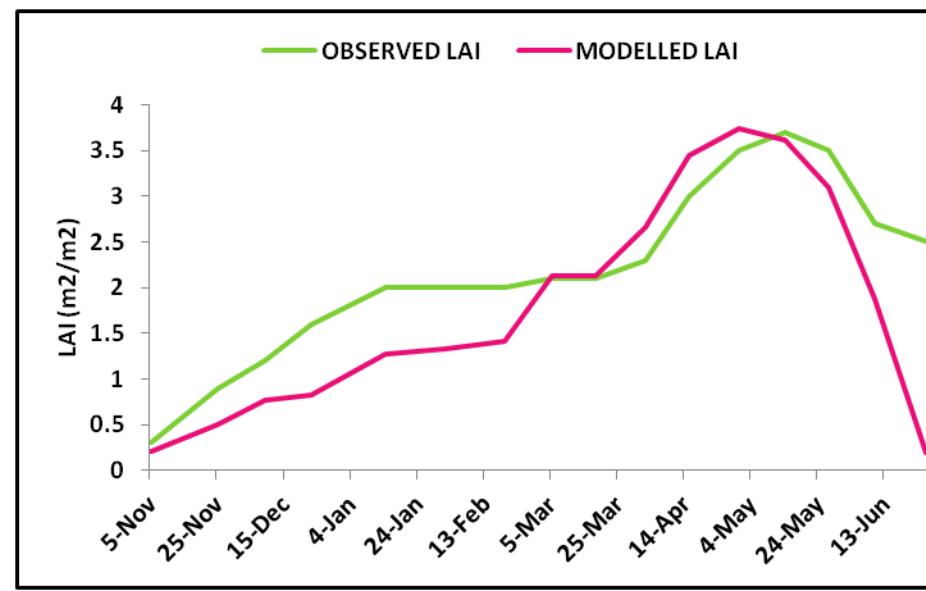
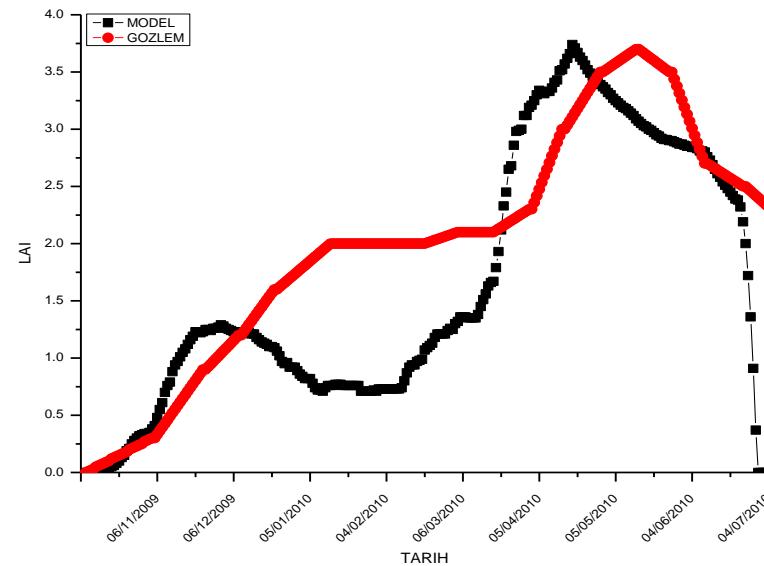
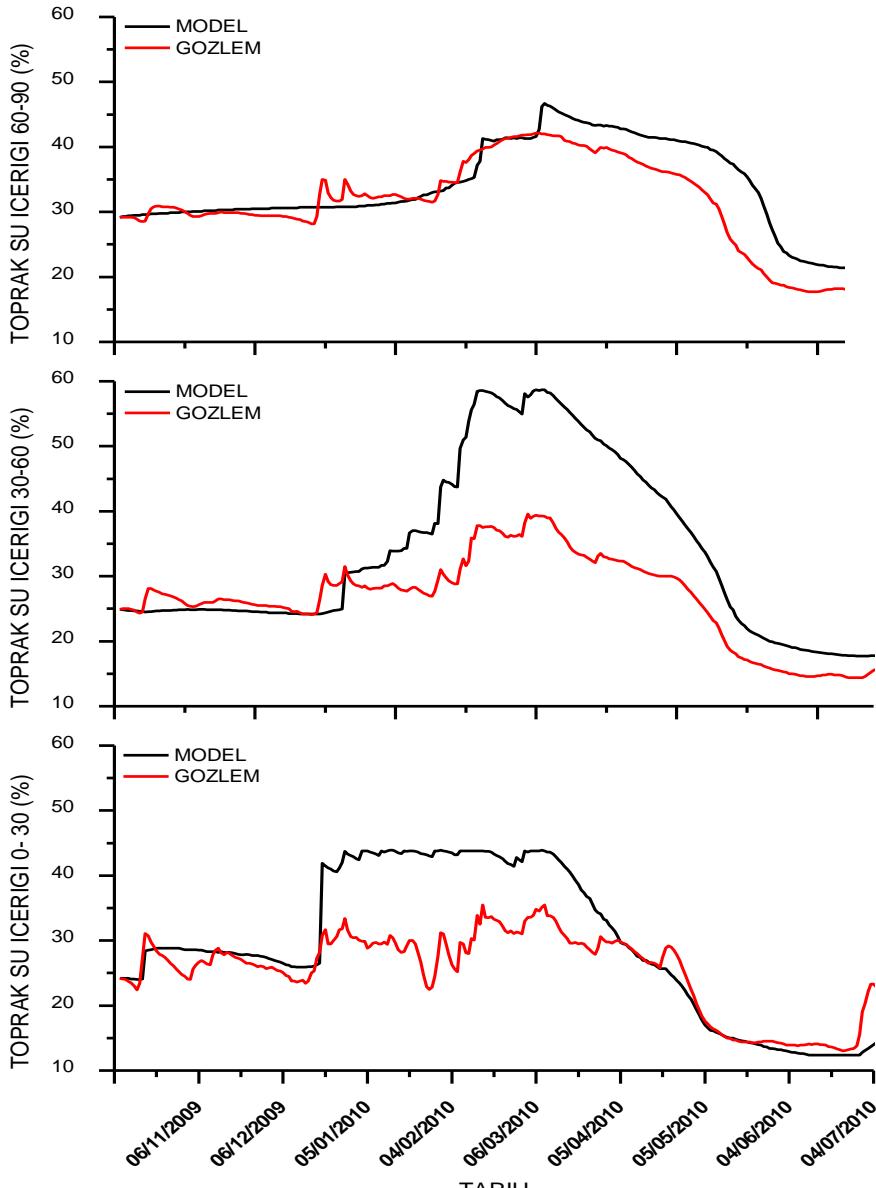
# NDVI & GDD (Winter wheat)



# Actual ET (Winter wheat)

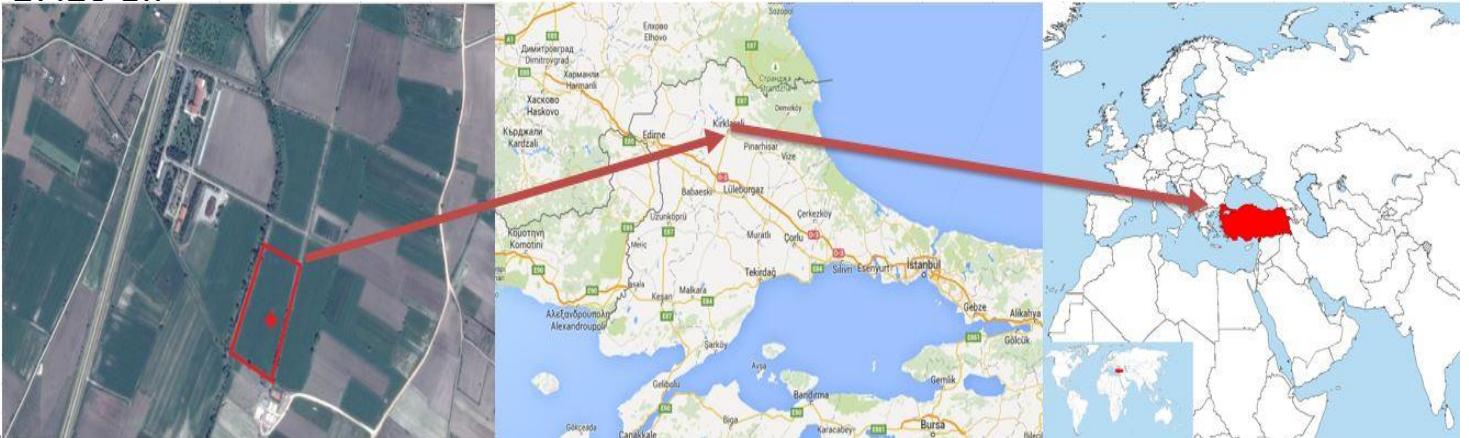


# Model vs actual



# Study Area

- Study area is located in Kırklareli city in northwest of Turkey (41.70 N, 27.20 E).



- It is a watermelon type.
- Watermelon type is crimson sweet.
- Growing period is between 14.05.2012 and 09.10.2012.
- The research territory belongs to a temperate, continental and Mediterranean climate, with an annual mean temperature of 13.2 °C (1950 – 2014). Long term annual mean total precipitation is 578 mm (TSMS, 2015).



# Experiment Area



# Measurements

- **Agricultural Meteorological Station Measurements;**

To examine the EC measurements simultaneously with meteorological variables like;

**maximum, minimum and mean temperatures, relative humidity** (Hygrometer MP100A, Rotronic Instrument Crop),

**wind speed and direction at 0.5, 1, 2, 5, 10 m level** (NRG #40C Anemometer and NRG #200P Wind Direction Wane, NRG Systems),

**global solar radiation** (CMP3, Kipp&Zonen),

**net radiation** (NR LITE, Kipp&Zonen),

**soil temperature at 2, 5, 10 and 20 cm level,**

**soil water content at 0-30, 30-60 and 60-90 cm** (CS 616 TDR type, Campbell Scientific)

were also measured during the experiment period.

- **Eddy Covariance Station Measurements;**

EC measurements were conducted using two types of sensors; namely a 3D sonic anemometer (CSAT3, Campbell Scientific) and an infrared gas analyzer (LI-7500, LI\_COR Biosciences) in a temporal resolution of 10 Hz.



# Eddy Covariance Method

## (lost data causes)

- Raw data has huge amount of error (up to % 40 in some cases).
- These data need to be detected and removed from original data set.

Causes of error;

- Frequency response is one of error cause.
- Precipitation for open path gas analyzer
- Wind direction (for fetch distance)
- Stable condition (calm wind)

Day	Hour	NEE umolm-2s	LE Wm-2	u* [m+1s-1]	Yağış mm/day
--	--				
27	0,5	2,784306	11,10669	0,09178	0
27	1	1,249825	7,097243	0,106888	0
27	1,5	2,755124	7,645899	0,102923	0
27	2	1,983535	7,106497	0,064805	0
27	2,5	3,328474	7,139049	0,07519	0
27	3	3,191534	3,210884	0,051834	0
27	3,5	2,809262	3,759758	0,082362	0
27	4	3,463168	6,829475	0,101726	0
27	4,5	3,429548	5,261592	0,079147	0
27	5	3,763016	7,802294	0,115801	0
27	5,5	2,72418	9,391052	0,064598	0
27	6	2,563435	24,89608	0,118936	0
27	6,5	0,970349	33,67526	0,125781	0
27	7	-0,35048	50,65669	0,124255	0
27	7,5	-1,42814	52,05116	0,162573	0
27	8	-3,75011	66,01104	0,164407	0
27	8,5	-3,56446	72,90005	0,170886	0
27	9	-1,83593	54,98096	0,151343	0
27	9,5	-1,00192	51,12685	0,157833	0
27	10	-36,966	213,5836	0,104452	0,1
27	10,5	0	-9999	0,085649	0,1
27	11	2,630054	53,44598	0,098419	0,1
27	11,5	6,594086	-41,2586	0,059746	0
27	12	-8,48387	171,5397	0,105433	0,1
27	12,5	-2,84819	155,0078	0,199122	0
27	13	-6,49119	230,5524	0,286641	0
27	13,5	-9,46306	225,1657	0,243375	0
27	14	-7,89726	191,0582	0,26716	0
27	14,5	-9,71515	160,9608	0,230556	0
27	15	-3,33931	93,01436	0,263746	0
27	15,5	0,000237	80,88807	0,249356	0
27	16	-0,41824	58,85051	0,22423	0
27	16,5	-0,35161	24,07106	0,200226	0
27	17	1,908178	37,42729	0,176232	0
27	17,5	2,730857	25,78739	0,109628	0
27	18	3,323802	22,82555	0,089522	0
27	18,5	4,781905	37,62476	0,221395	0
27	19	-2,5007	38,63009	0,189526	0,1
27	19,5	-41,6537	276,0666	0,157222	0,1
27	20	0	-9999	0,148764	0,1
27	20,5	0	-9999	0,137891	0,1
27	21	-21,3335	202,4343	0,200557	0
27	21,5	2,436591	30,48973	0,199598	0
27	22	2,29391	10,55217	0,076495	0
27	22,5	-0,50846	18,62024	0,103561	0
27	23	2,880636	23,36463	0,118142	0,1
27	23,5	27,43376	-103,235	0,0236	0,6

# Eddy Covariance's Pros and Cons

EC method allow to measure ET directly with high accuracy. Therefore it is most common used method to measure fluxes in the World.

Disadvantages of method can be summarized as;

- Cost of system,
- Necessity of experience of agricultural meteorological to amounting system,
- Frequent study work for cleaning and Aletlerin temizliği ve bakımları için sık zaman aralıklarında araziyi ziyaret etme zorunluluğu,
- Detecting wrong data and gap filling procedure.

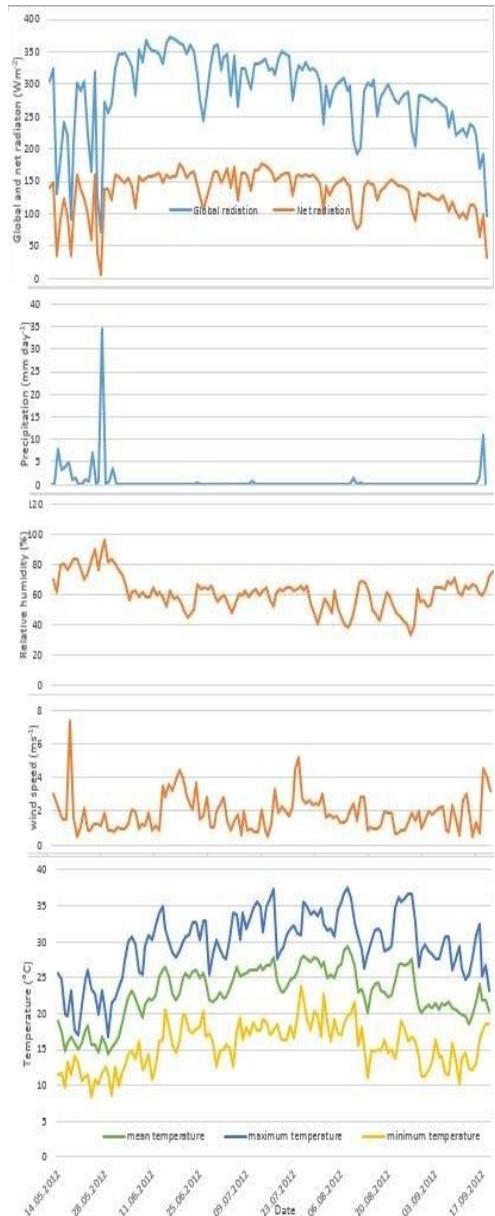
# Results – Variations of Meteorological Parameters

- Total precipitation during growing period was 88.2 mm.

During May, 71.4 mm precipitation occurred.

- As expected, temperature variations were getting higher values during summer months but lower in May caused by below climate averages because of rainy days.
- Global and net radiation values together with relative humidity were also lower in May than the rest of the growing period.

	May	June	July	August	September
Monthly total precipitation (mm) (long term)	50.0	50.6	26.8	20.8	34.5
Monthly total precipitation (mm) (2012)	68	3.9	1.1	1.9	12.8
Average temperature (°C) (long term)	17.3	21.6	23.9	23.3	19.1
Average temperature (°C) (2012)	15.49	22.75	25.12	23.76	20.22



# Results - Footprint

Flux footprint was calculated via;

- EC systems height
- Vegetation height
- Atmospheric condition (stable, unstable or neutral) by model of Kljun ve et al. (2004).

Model assumes following conditions;

- Measurement height < boundary layer height
- Homogen area
- Measurement height  $\geq 1 \text{ m}$

As a result % 90 of flux is in study area.

Contribution percentage of data to flux measurement (%)	Distance from measurement point (m)
Free area (no contribution)	2
% 10	3.86
% 30	7.47
% 50	13.22
% 70	26.07
% 90	92.08

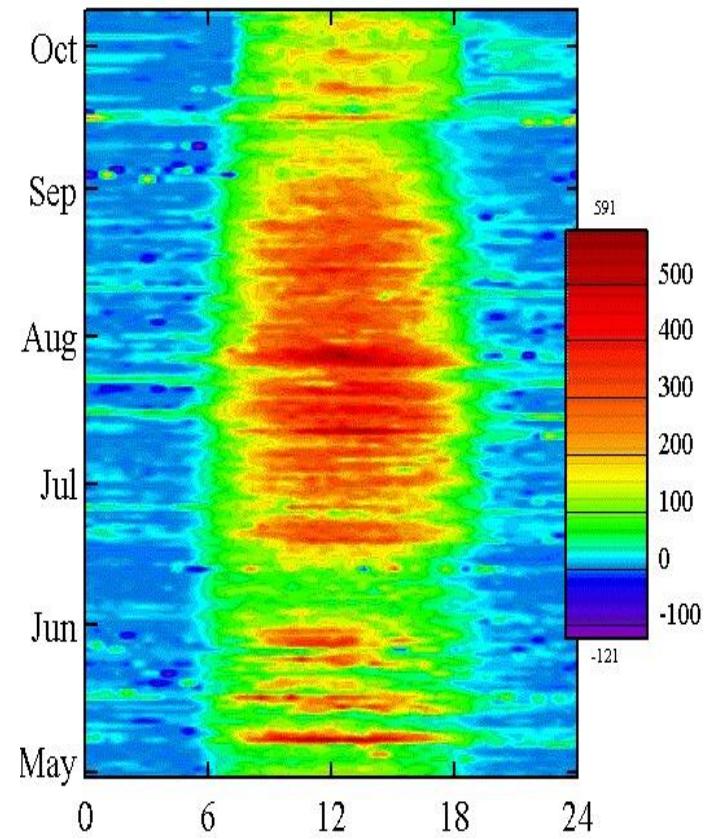
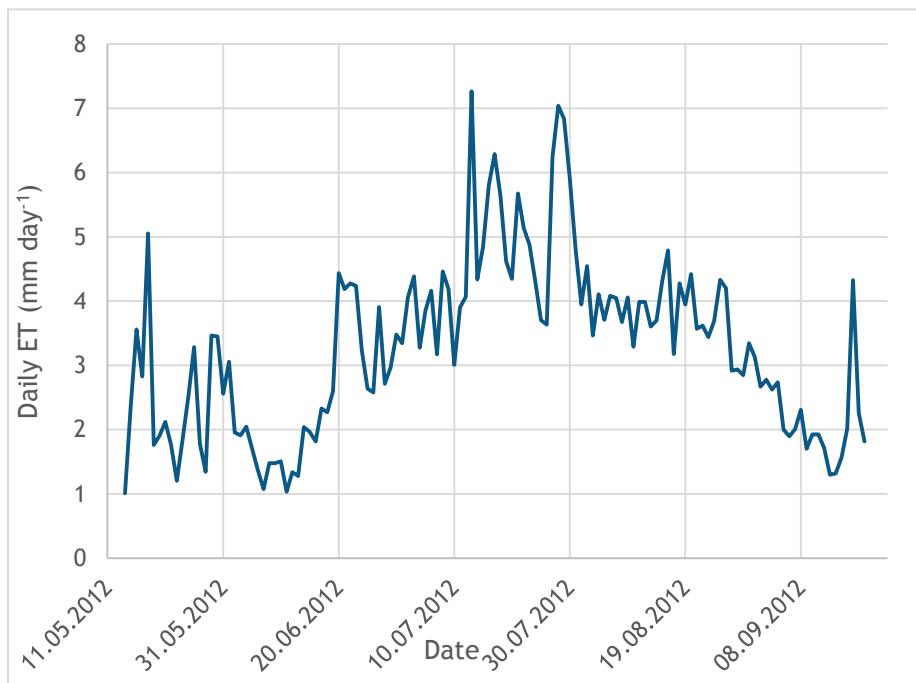
# Results – Variations of ET

Total  $ET_a = 422 \text{ mm}$

Maximum  $ET_a = 7.26 \text{ mm day}^{-1}$  at 13/07/2012

Minimum  $ET_a = 1.01 \text{ mm day}^{-1}$  at 14/05/2012

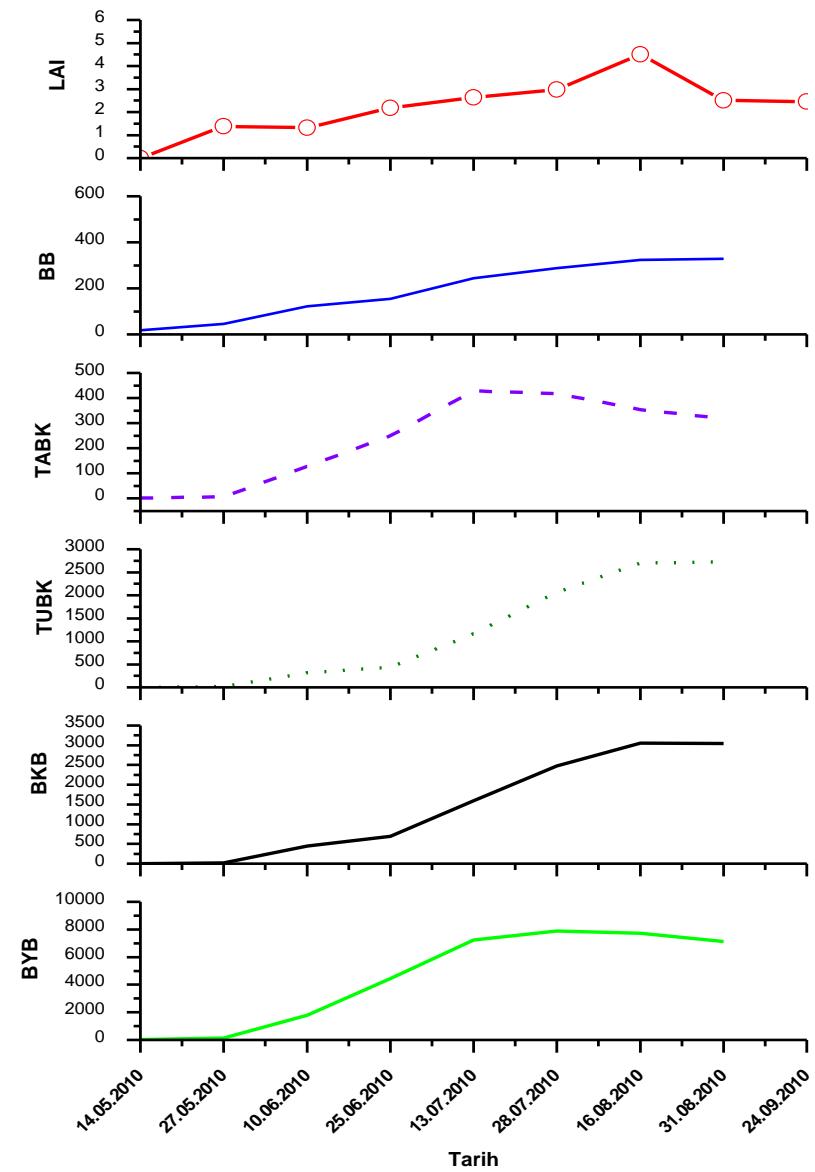
Daily mean  $ET_a = 3.27 \text{ mm day}^{-1}$



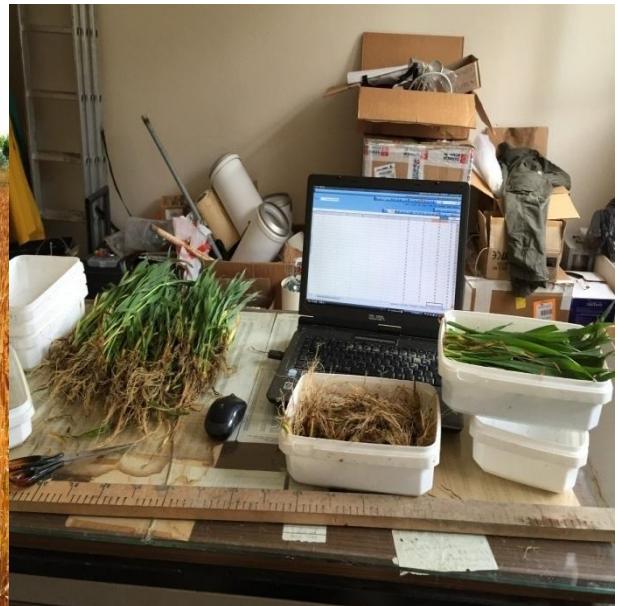
# Agrometeorological stations



# Phenological observations



# Field works



# EDDY COVARIANCE





Infrared Gas Analyzer  
(IRGA) for CO<sub>2</sub> and H<sub>2</sub>O  
Flux

Sonic  
anemometer

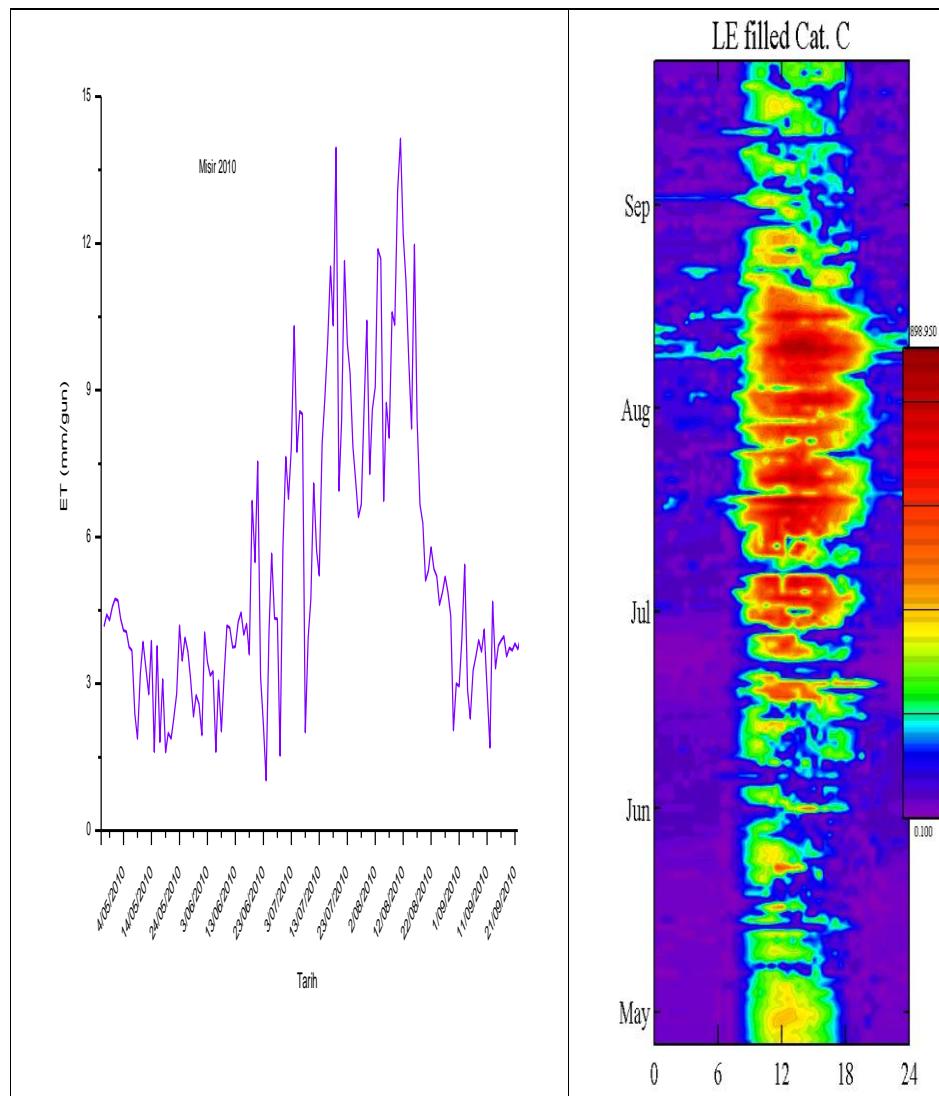
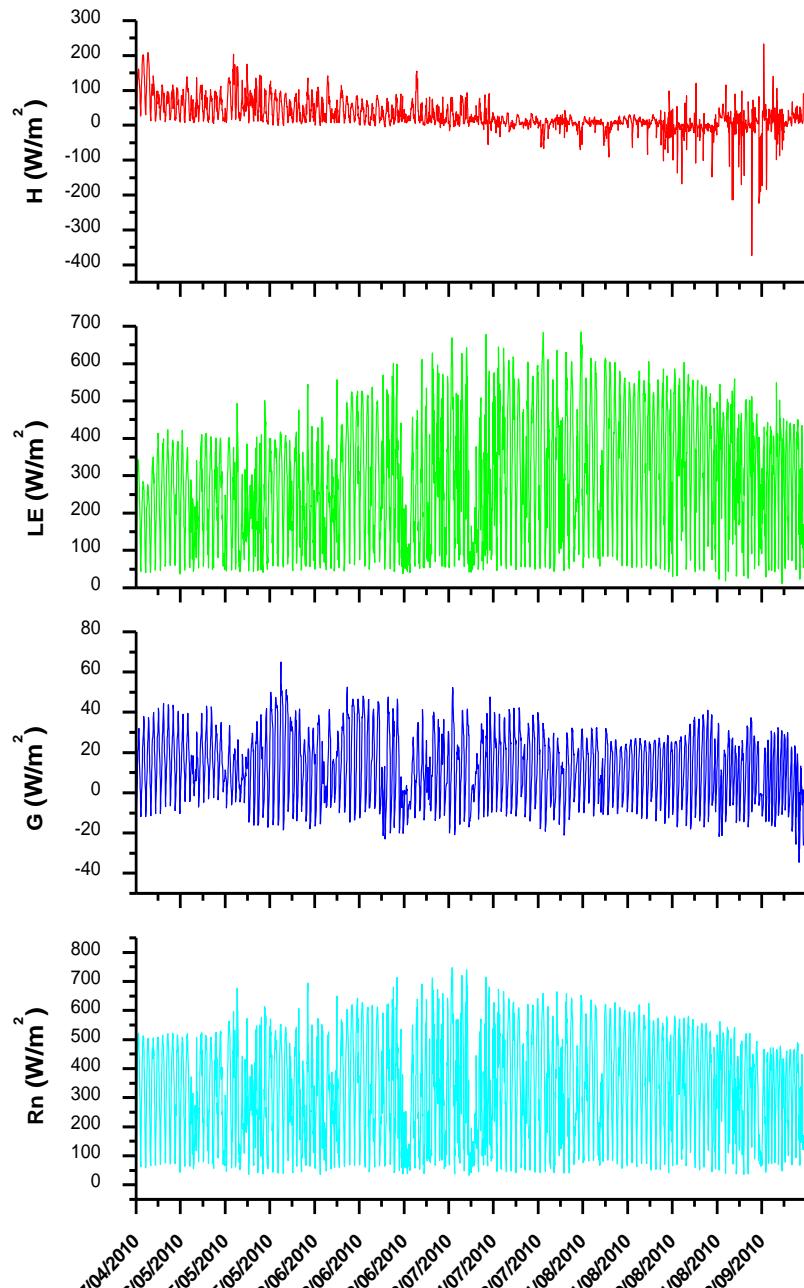
24 6 2005

# Flux measurement (Bowen Ratio Energy Balance)

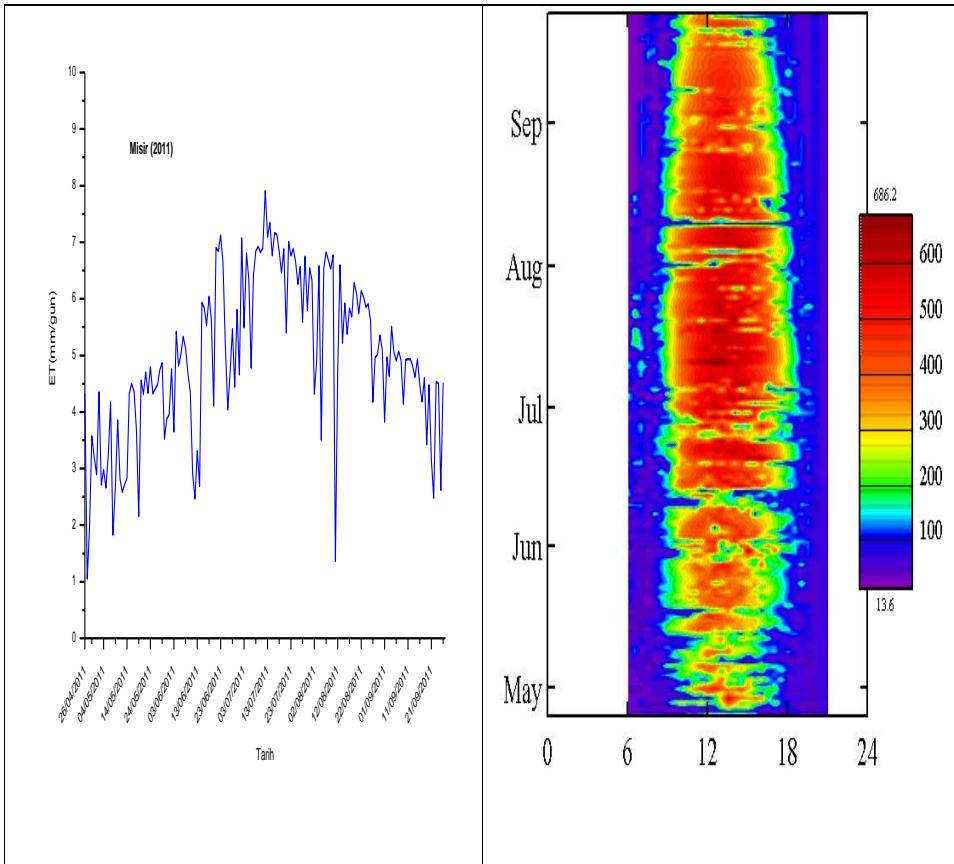
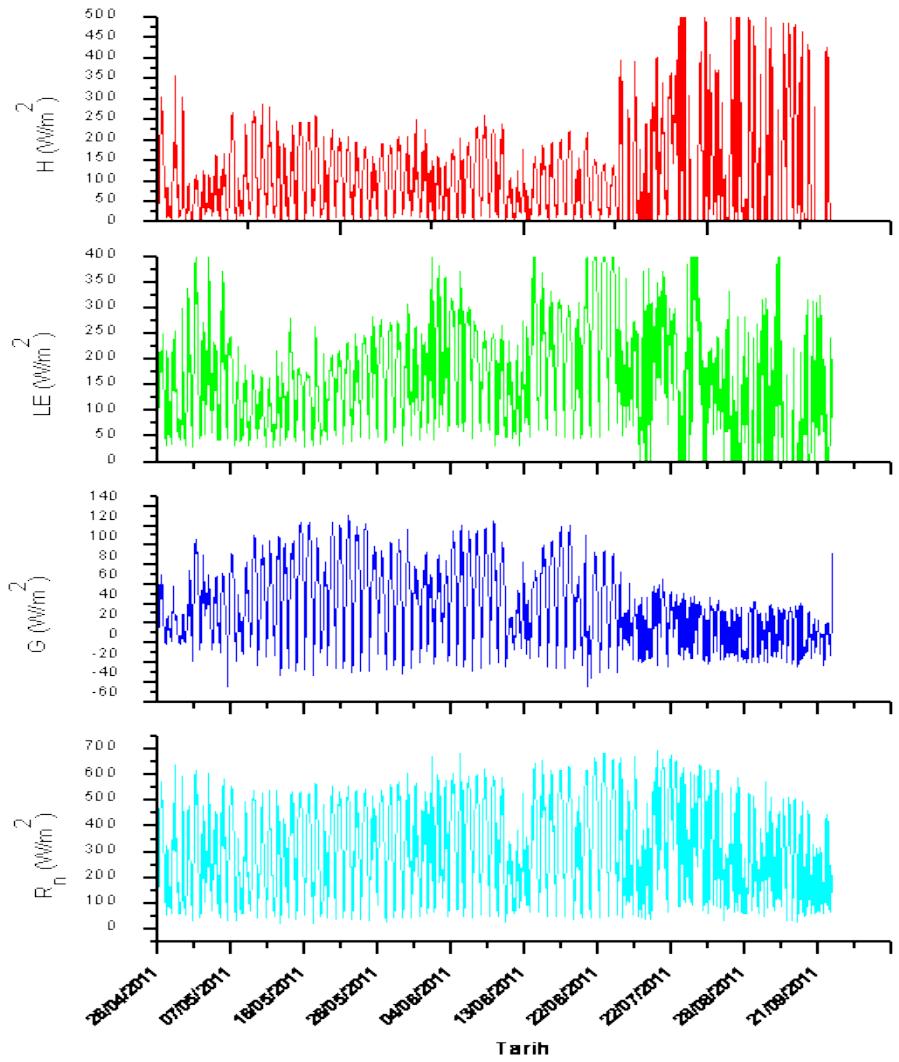


Misir 2009-201

# 2010 growing season

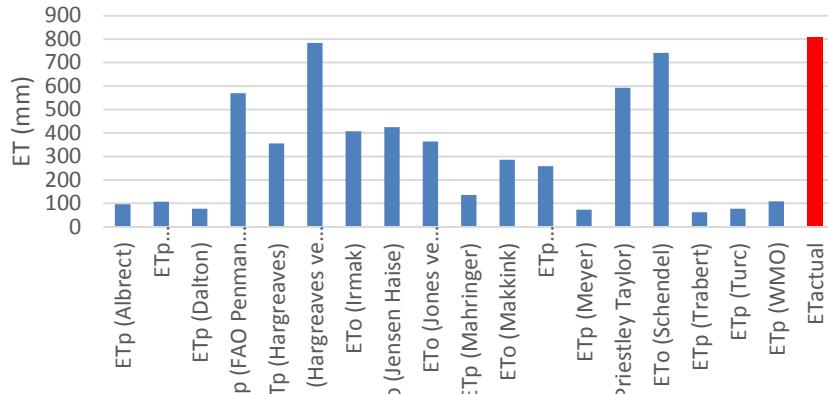


# 2011 Growing season

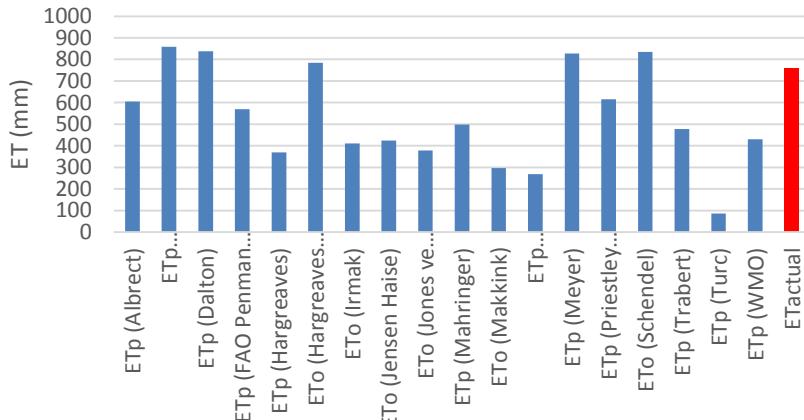


# RESULTS

Maize Total ET Values for 2010 Growing Season

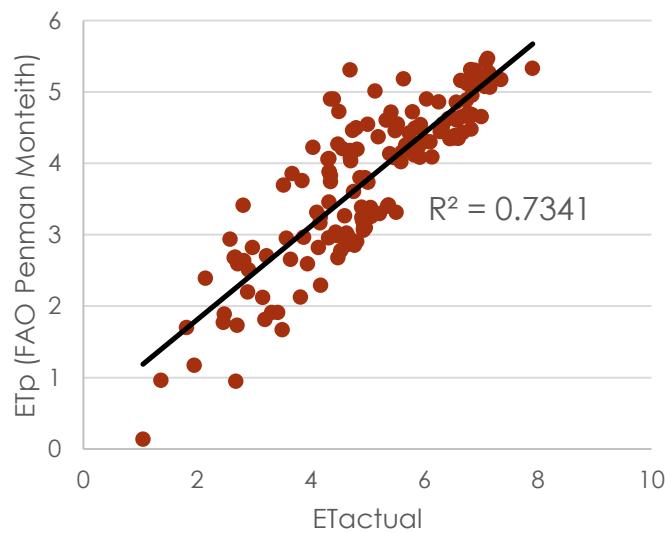
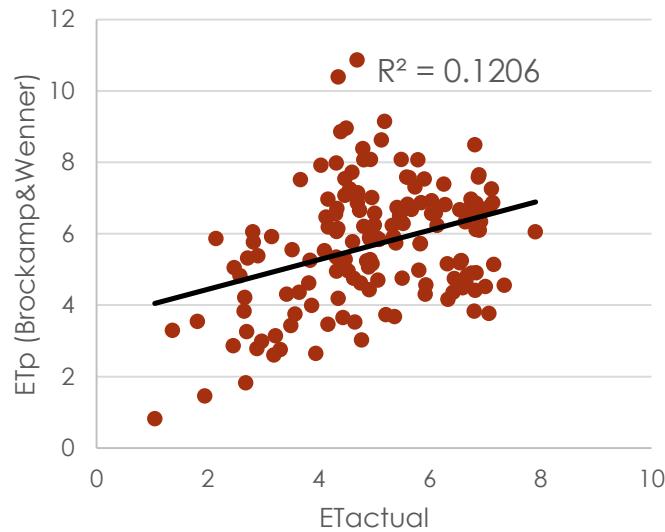
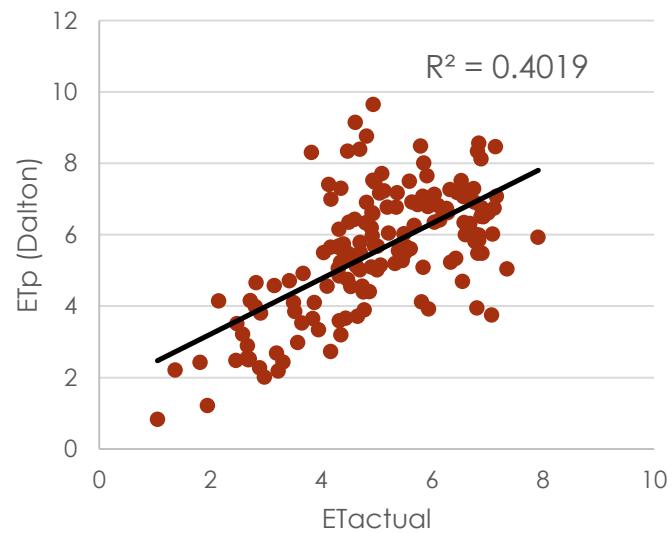
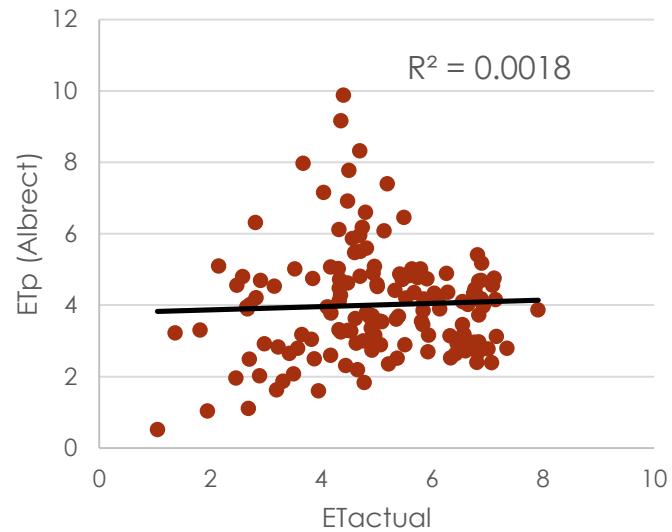


Maize Total ET Values for 2011 Growing Season

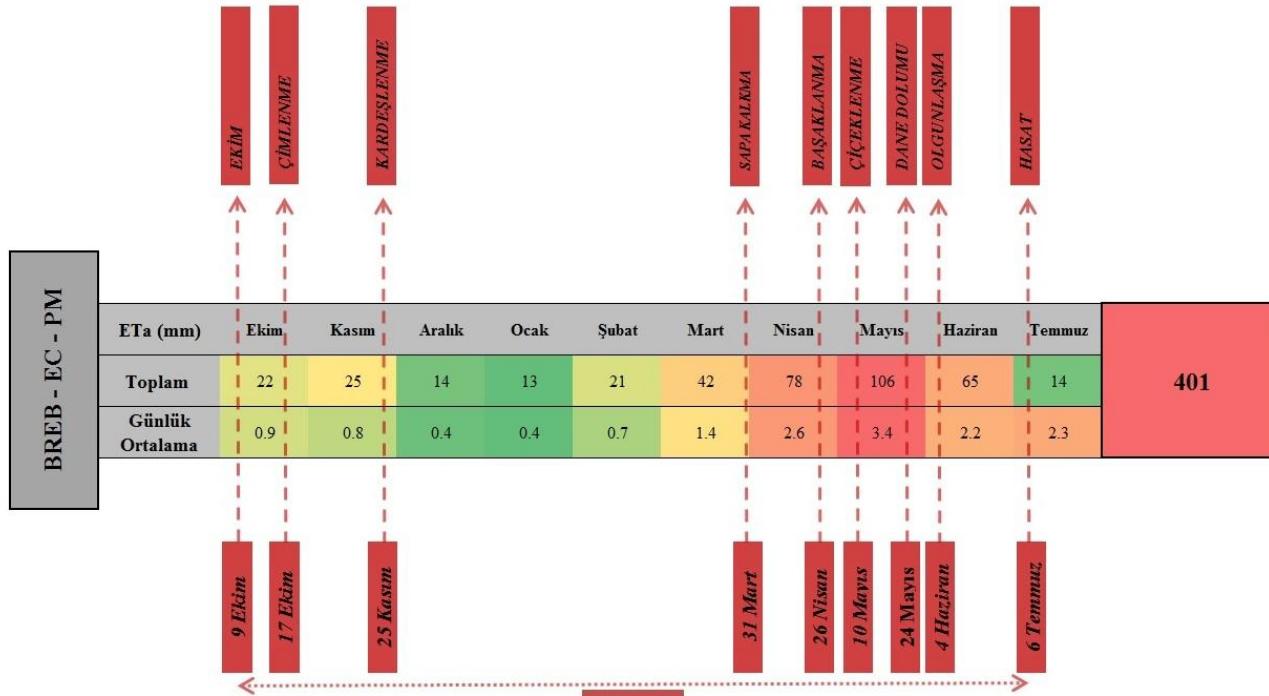


	2010 TOTAL ET (mm)	2011 TOTAL ET (mm)
ETp (Albrecht)	96	605
ETp (Brockamp&Wenner)	107	859
ETp (Dalton)	77	837
ETp (FAO Penman Monteith)	569	569
ETp (Hargreaves)	355	369
ETo (Hargreaves ve Samani)	784	784
ETo (Irmak)	407	411
ETo (Jensen Haise)	425	425
ETo (Jones ve Ritchie)	363	377
ETp (Mahringer)	136	499
ETo (Makkink)	285	296
ETp (McGuinness&Bordne)	259	268
ETp (Meyer)	73	828
ETp (Priestley Taylor)	592	616
ETo (Schendel)	741	835
ETp (Trabert)	62	477
ETp (Turc)	77	85
ETp (WMO)	109	430
ETactual	808	755

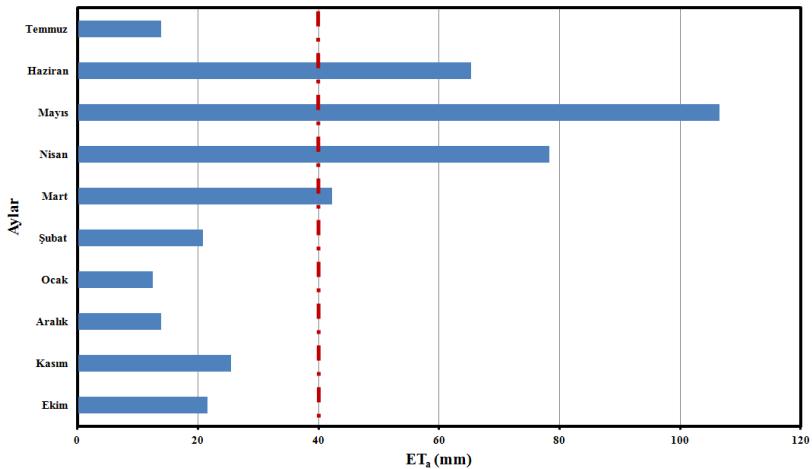
# RESULTS



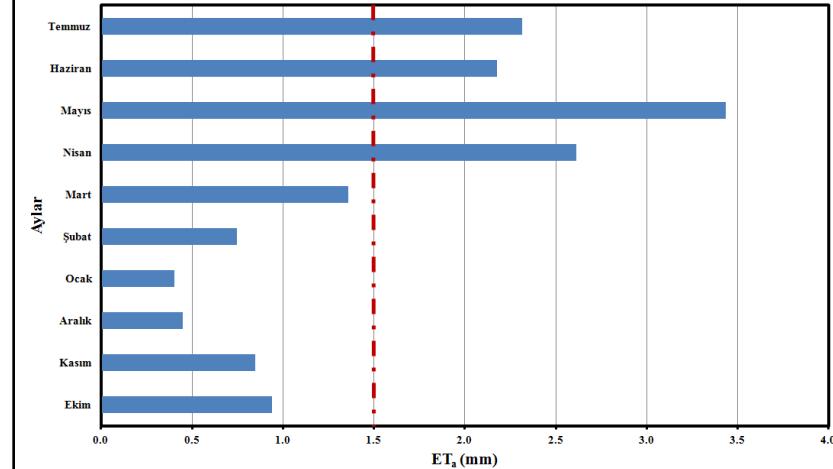
# Results

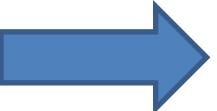


BREB - EC - PM ile Elde Edilen  
Aylık Toplam Evapotranspirasyon Değerleri



BREB - EC - PM ile Elde Edilen  
Günlük Ortalama Evapotranspirasyon Değerleri



- BREB – EC   $R^2 = 0.71$
- BREB – PM   $R^2 = 0.71$
- EC – PM   $R^2 = 0.51$

- IN ORDER TO MANAGE WATER BETTER IN ARID AND SEMI ARID COUNTRIES, WE SHOULD MORE CONSANTRATE ON THE APPLIED STUDIES FOR THE MEASUREMENT OF WATER CONSUMPTION OF CROPS.
- MICROMETEOROLOGICAL METHODS ARE ONE OF THE ALTERNATIVES TO MEAUSURE ACTUAL GREEN WATER (Crop ater use).

# COMPARISON OF SOIL CO<sub>2</sub> FLUX FROM AN AGRICULTURAL LAND SURFACE UNDER ARID CONDITIONS

Elif Didem Gölle Sakin<sup>1</sup>, Levent Saylan<sup>2</sup>, Serhan Yeşilköy<sup>3</sup>,

Erdal Sakin<sup>4</sup>

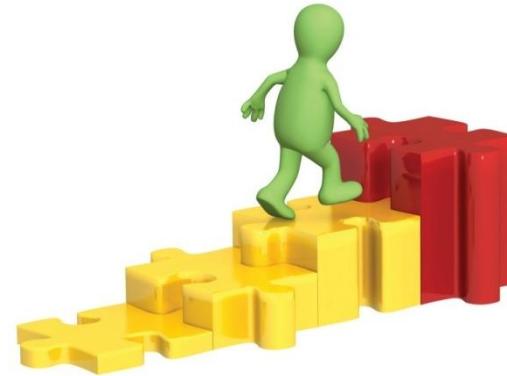
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<sup>2</sup> Istanbul Technical University, Faculty of Aeronautics and Astronautics, Department of Meteorology, İstanbul.

<sup>3</sup> Atatürk Soil Water and Agricultural Meteorology Research Institute Directorate, Kırklareli  
Harran University, Şanlıurfa



# PURPOSE



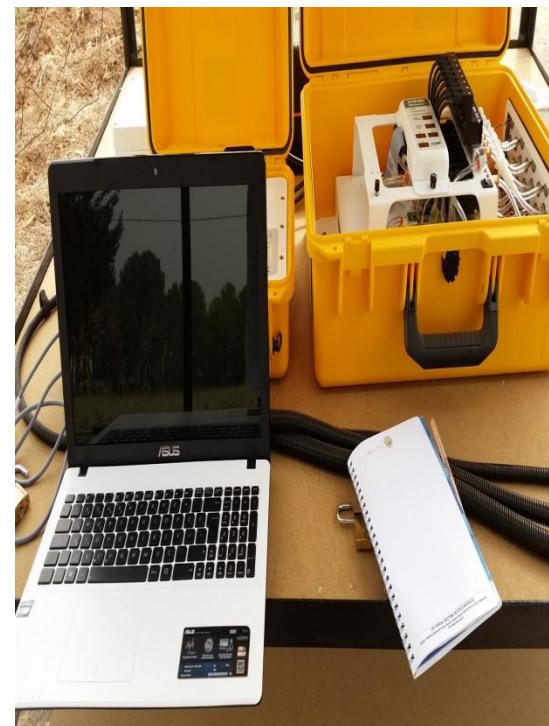
- TO COMPARE CO<sub>2</sub> FLUX FROM THE CULTIVATED, UNCULTIVATED, PLANTED SOIL SURFACES UNDER EXTREME TEMPERATURE CONDITIONS.

# MATERIALS

- 2 DIFFERENT DYNAMIC CHAMBERS
- GAS ANALYZER
- MULTIPLIXER
- SOIL MOISTURE SENSORS
- SOIL TEMPERATURE SENSORS
- OTHER METEOROLOGICAL DATA OBTAINED FROM STATE MET: SERVICE STATION LOCATED AT THE SAME PLACE



# MATERIALS



- This project is the first study about measuring carbon dioxide fluxes using eddy covariance method over winter wheat in Turkey.
- These measurements must be done continuously to be able to obtain more reliable results.
- For this reason a carbon flux network may be created in Turkey.
- Determining relationships between carbon fluxes and vegetation dynamics may help to estimate carbon fluxes for wide areas.





**THANK YOU FOR YOUR  
ATTENTION!**