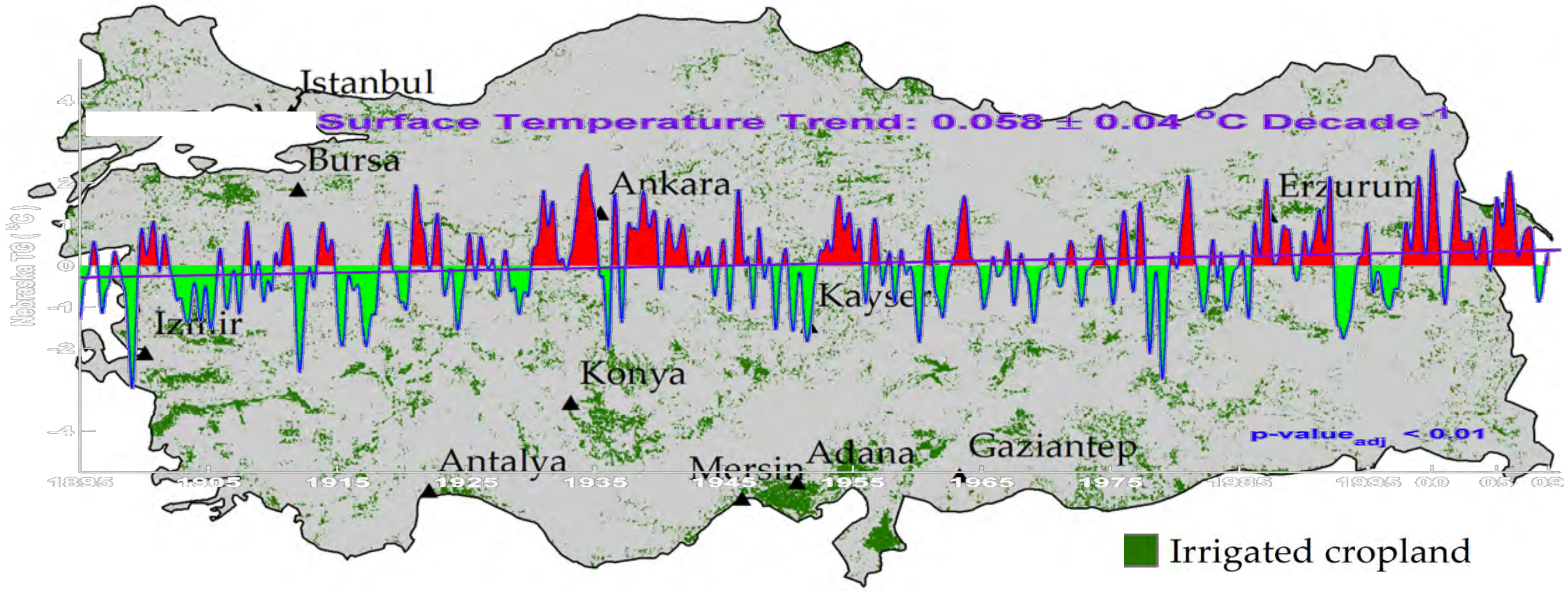



# Changes in magnitudes and trends in climate variables and implications to water resources, agriculture and policies in Türkiye

***Suat Irmak, Ph.D.***
***Distinguished Professor***
***University of Nebraska-Lincoln***
***sirmak2@unl.edu (402) 472-4865***

# Importance of Agriculture

Agriculture has been an instinctive and vital part of human civilization and has been significantly contributing to the food security and aiding in reducing poverty since its beginning in about 8,000-10,000 B.C. by the Sumerians of Mesopotamia [Iraq and southeastern Anatolia (Modern Turkish Republic)] where the remains of the first man-made water delivery systems/canals still exist.

By 5,000 B.C., Egyptians were the first civilization who developed core agricultural techniques, including large-scale intensive cultivation of land, mono-cropping, and organized irrigation techniques using a form of canal irrigation with water purposely diverted from the Nile River.

# Importance of Agriculture

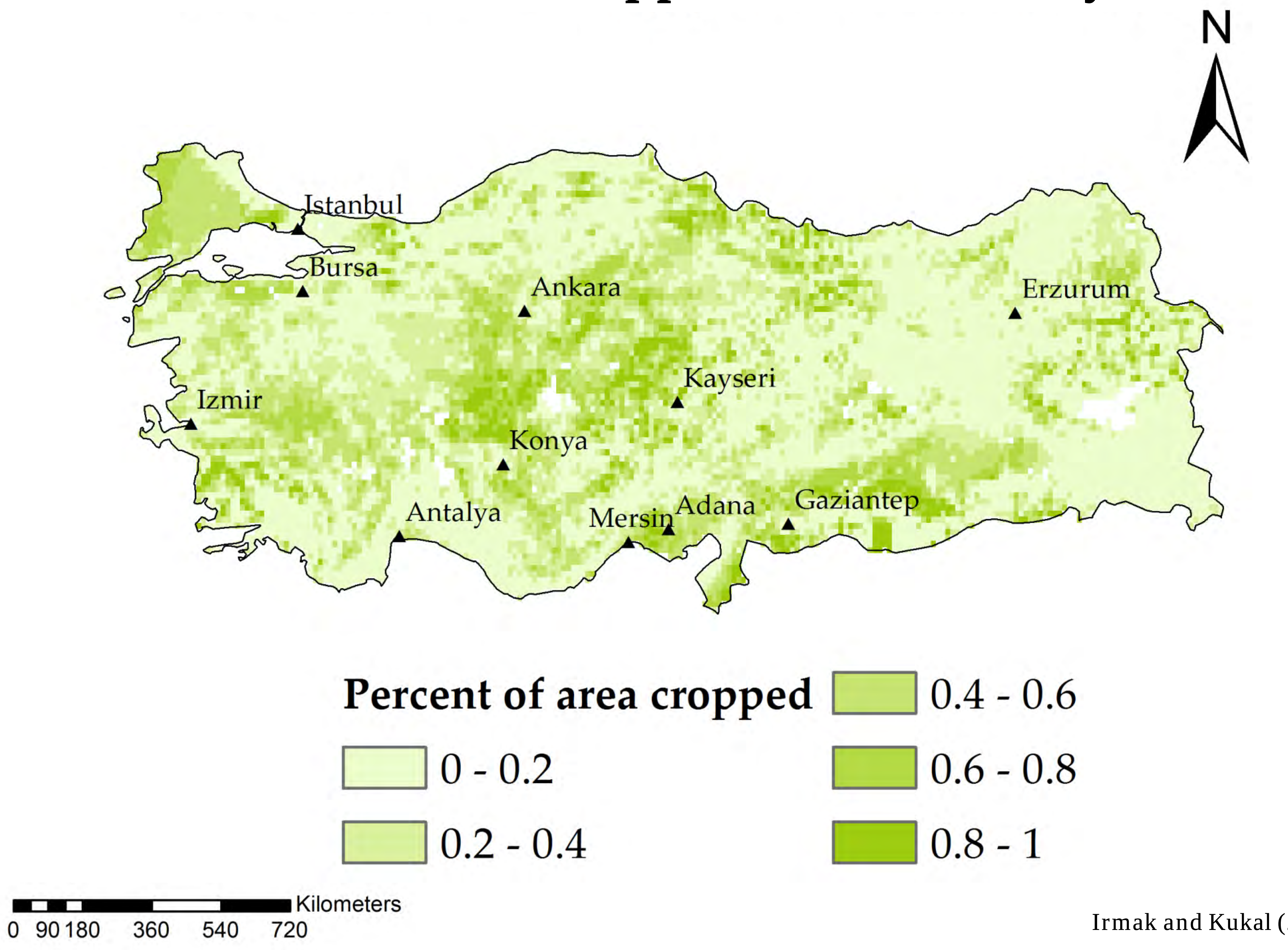
Today, irrigation continues to play a crucial role in meeting the food and fiber demand of a rapidly growing modern civilization as irrigated agriculture currently contributes to about 40% of the world's total food and fiber production on only (irrigated) 20% of the total cultivated land.

Türkiye has a robust agricultural and food industry that employs about 20% of the country's working population and accounts for 6.1% of the country's GDP in 2016. Agriculture’s financial contribution to the overall GDP increased 40% from 2002 to 2016, reaching $52.3 billion in 2016. Türkiye is the world’s 7th largest agricultural producer overall.

# Arable land - Türkiye

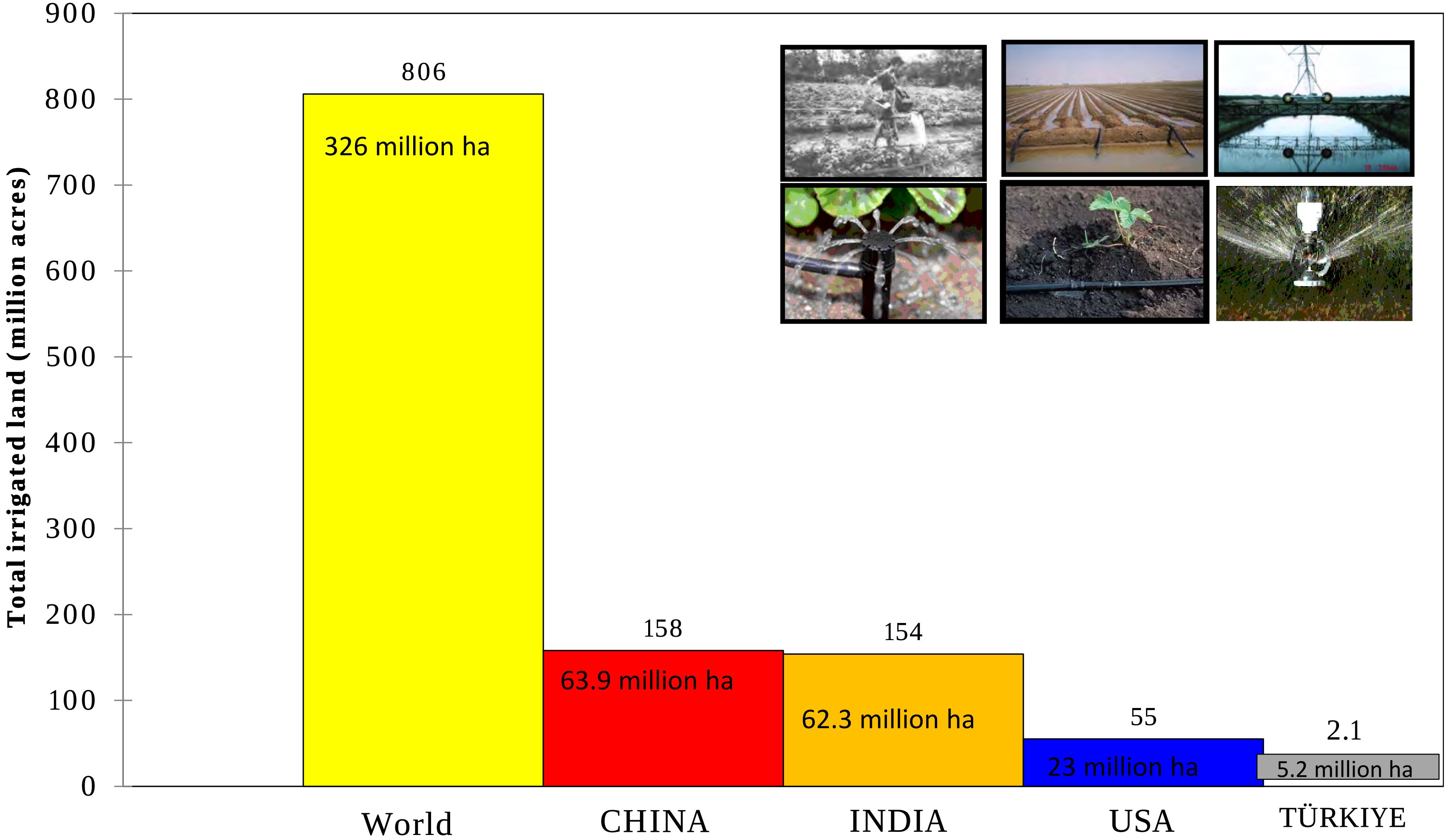

Türkiye reported a total of 20,645,000 ha (about 36% of the total area of the country) of arable land in 2015, according to the World Bank collection of development indicators.

# Distribution of cropped area in Türkiye

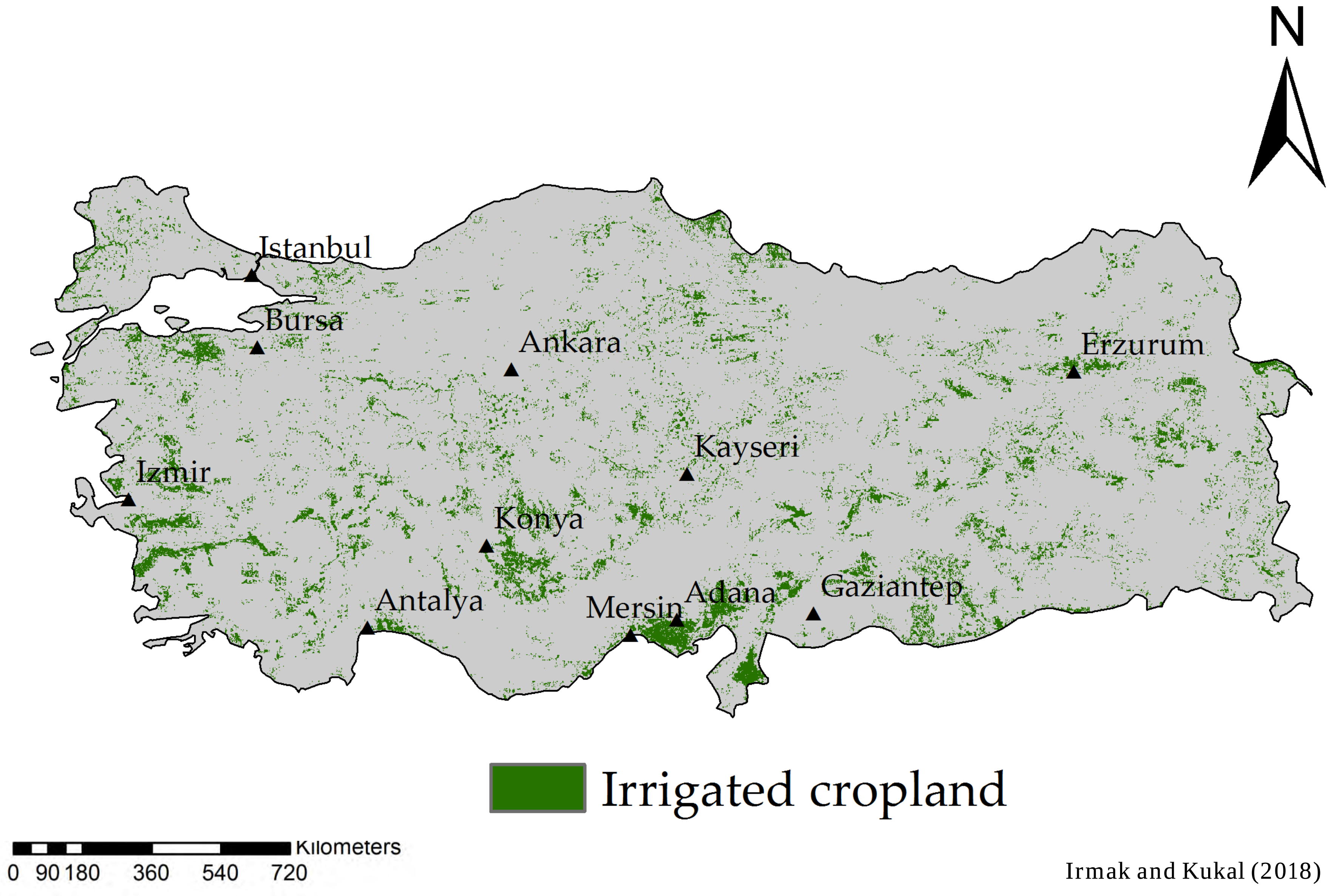



Irmak and Kukal (2018)

# Irrigated land area - World



# Distribution of irrigated crops in Türkiye




Irmak and Kukal (2018)

# Climate's interactions and impacts

Changes in climate variables interact with and impact agricultural and agro-ecosystem productivity and land surface-atmosphere relationships through various direct and indirect processes, including:

- Increased air temperature and/or $CO_2$ concentration
- Changes in solar radiation reaching the earth's surface
- Changes in atmospheric vapor pressure
- Changes in hydrologic parameters such as precipitation, run-off, stream flow, deep percolation, infiltration rate
- Changes in intensity and frequency of wild fires
- Changes in dynamics of pests and diseases
- Changes in land use/land cover
- Afforestation, and deforestation
- Wildlife habitat
- Impacts on human health
- Impacts on animal agriculture

# Quantitative knowledge

Changes in climate variables can have direct impact on agricultural productivity. For example, a small increase in Tmax or Tmin can have substantial impact on some of the physiological functions of crops, which in turn impact crop growth, development and yield, even under well managed farming operations.

Air temperature, especially can alter numerous fundamental plant phenological and physiological functions and agricultural practices and productivity indices.

Increase Tair, Rs and VPD can negatively impact water resources.

# Quantitative knowledge

- Warming of the earth's atmosphere by 1.5$^{o}$C since the late 19$^{th}$ century has been reported.

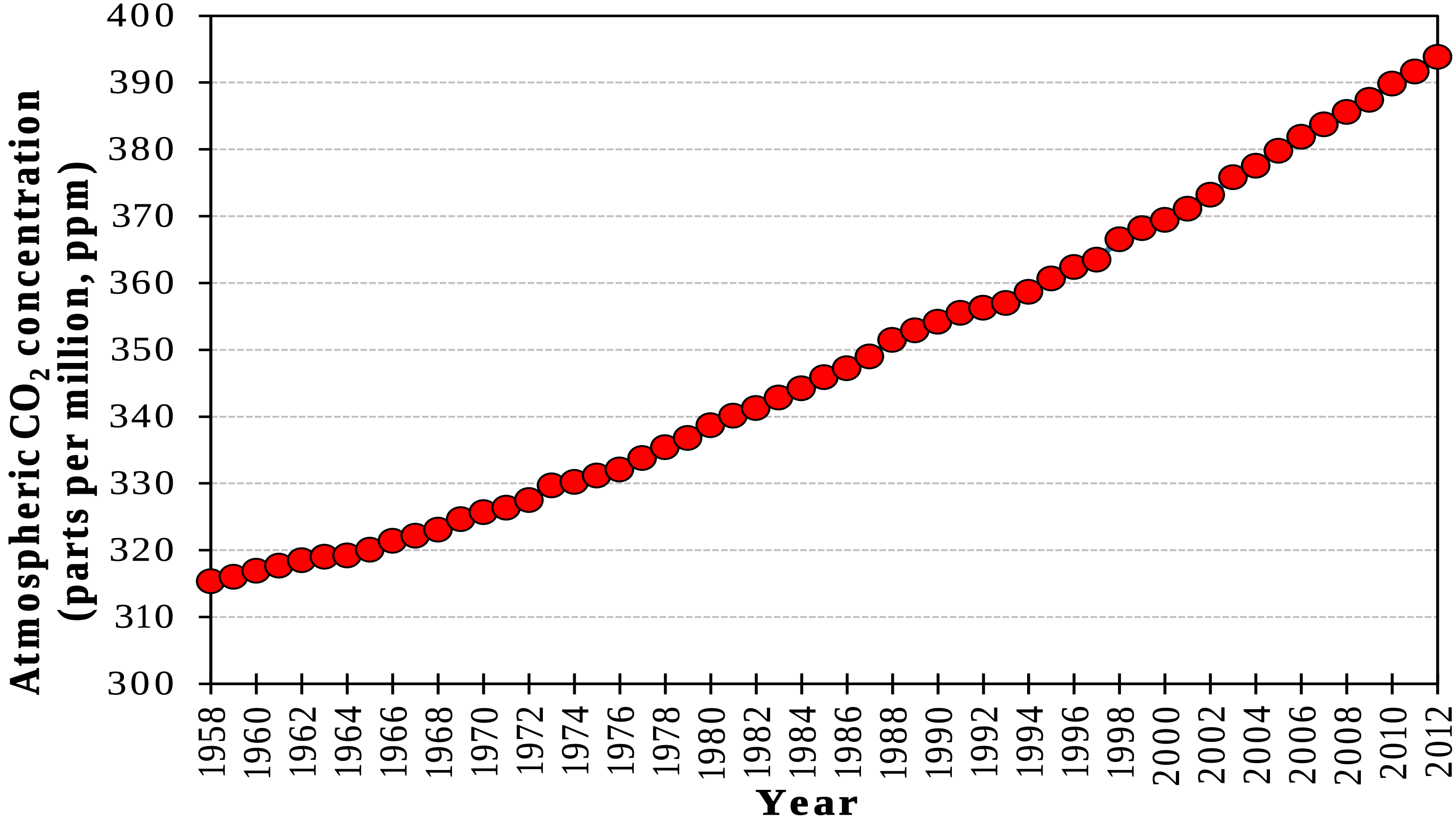
- These warming trends are most likely a result of the combination of growth of greenhouse gas emission (external) and natural changes in air temperature.

- Irmak et al. (2012) observed increases of 3.8°C and 1.9°C in daily minimum and average air temperature, respectively, from 1893 to 2012 at Central City in central Nebraska.

- Skaggs and Irmak (2013) observed that growing season length (**up to 17 days!**), early spring and late fall frost-free days are exhibiting significant changes.

- The global mean land-surface air temperature has risen by about 1$^{o}$C over the past 100 years (1906-2015) and is predicted to increase even more by 1.5-2.0$^{o}$C to 6.4$^{o}$C by 2100 (IPCC, 2018).

- Extreme events are increasing, wet is getting wetter and dry is getting drier.



Annual mean atmospheric $CO_2$ concentration measured at Mauna Loa, Hawaii (www.esrl.noaa.gov) (Irmak, 2013).

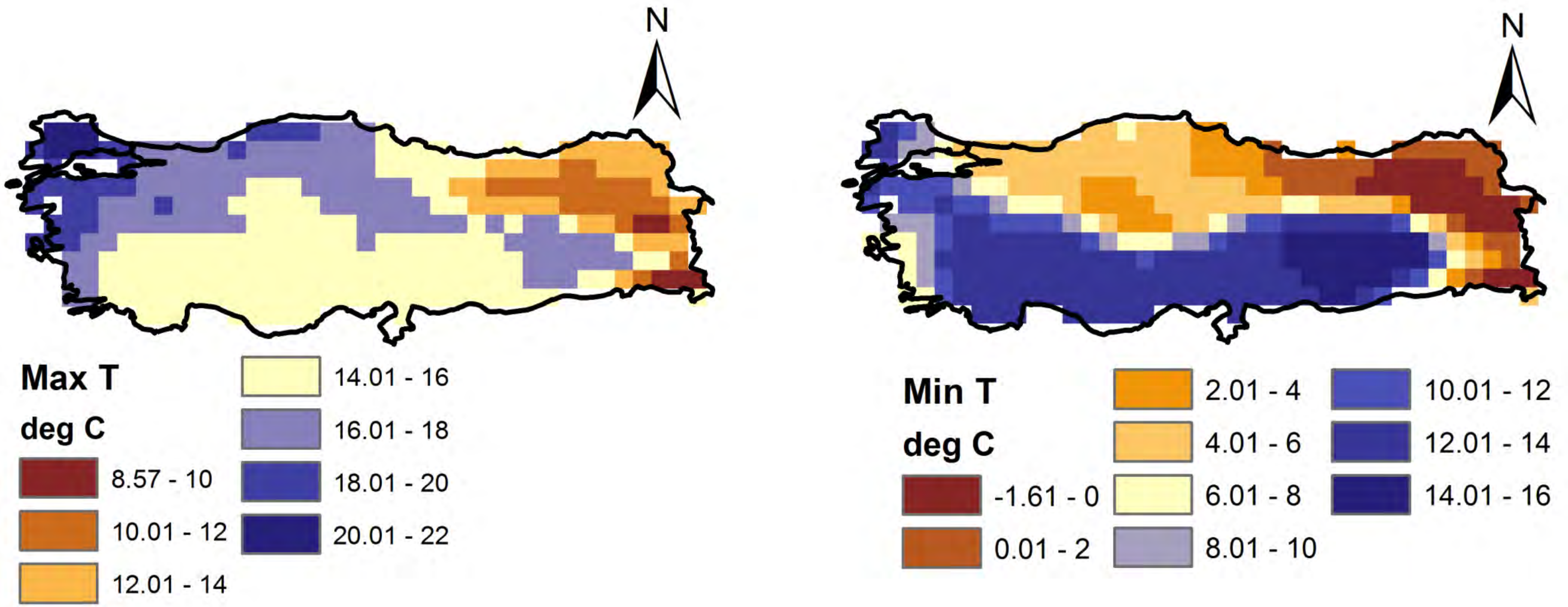
The atmospheric $CO_2$ concentration ($CO_2$ mole fractions) measured at Mauna Loa, Hawaii (a location where atmospheric contamination from greenhouse gas emissions is minimal) has increased ($P<0.05$) from 315.71 parts per million (ppm) in March 1958 to 412 ppm in December 2017 (24% increase) with a rate of 1.468 ppm per year since 1958.

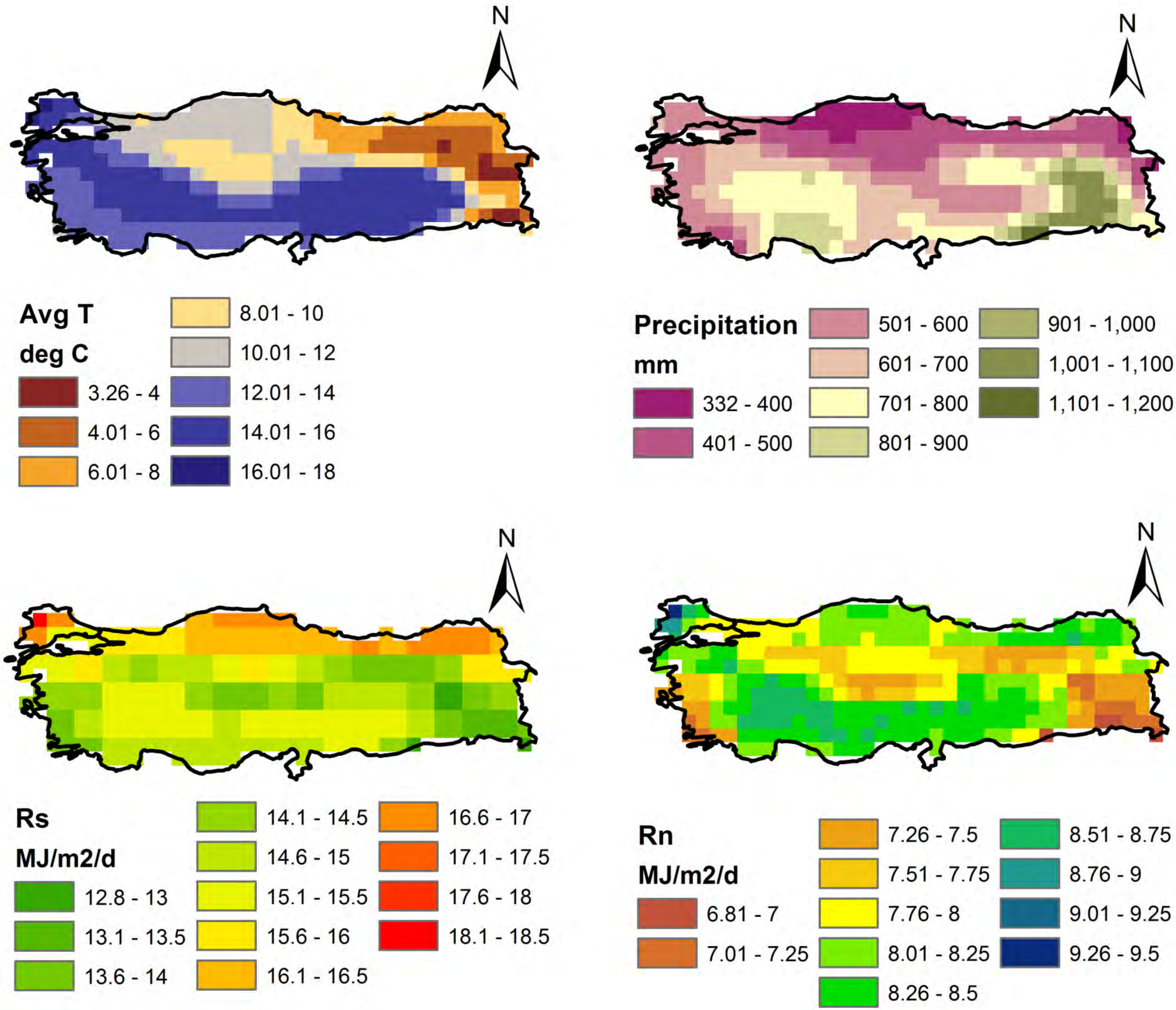
# Importance of locality and spatial attribute of climate impacts

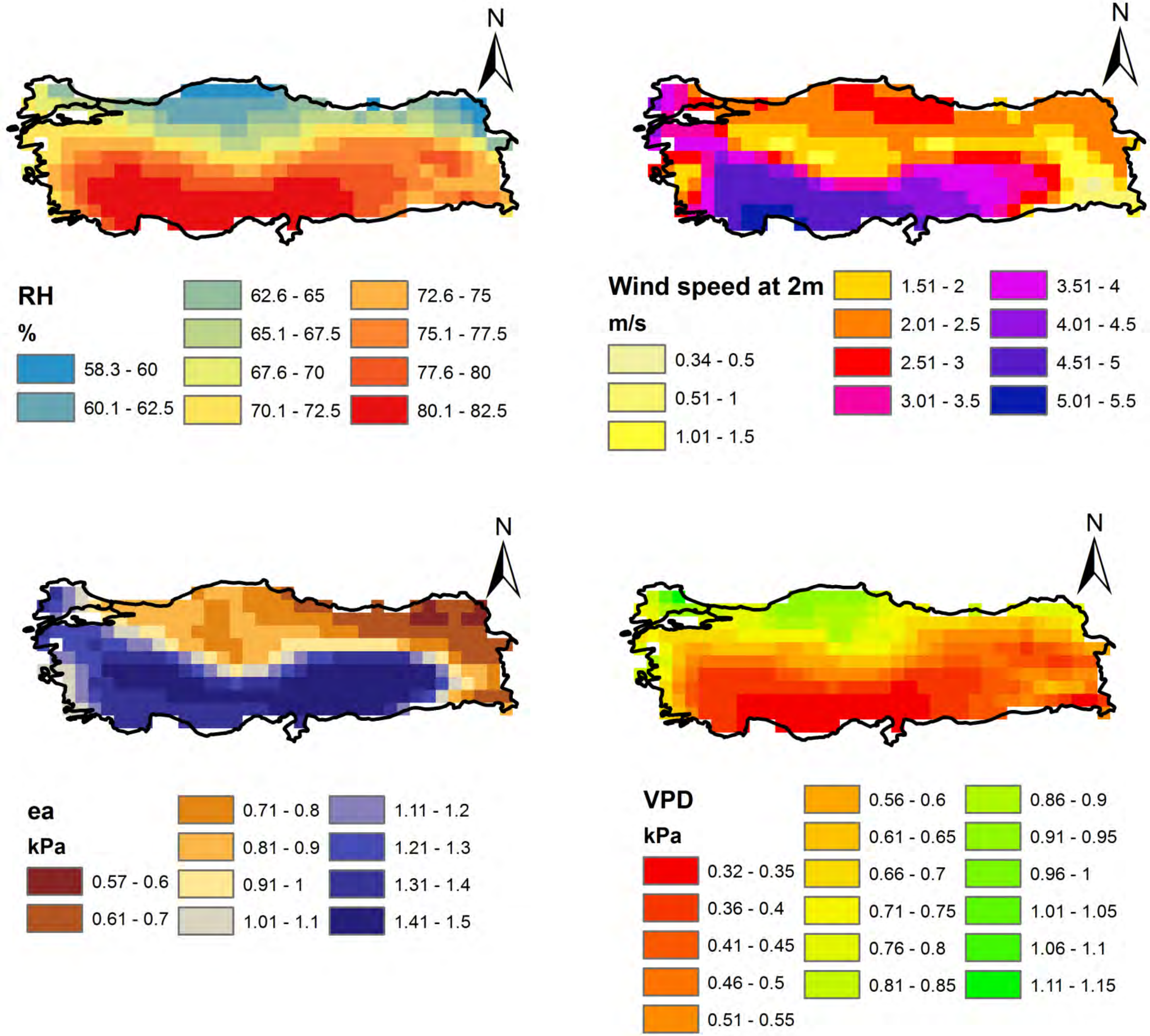
- While these increases in air temperature and $CO_2$ concentration may seem to be small for humans, the implications of these small increases in air temperatures for plant physiological functions and, in turn, their impact(s) on agricultural practices and productivity can be significant.

- ***While so much discussion and analyses take place on global climate change, it is imperative that the analyses are conducted for local/regional conditions so that local changes can be documented and local best agricultural and water resources management practices can be developed in response to changes in climatic variables.***

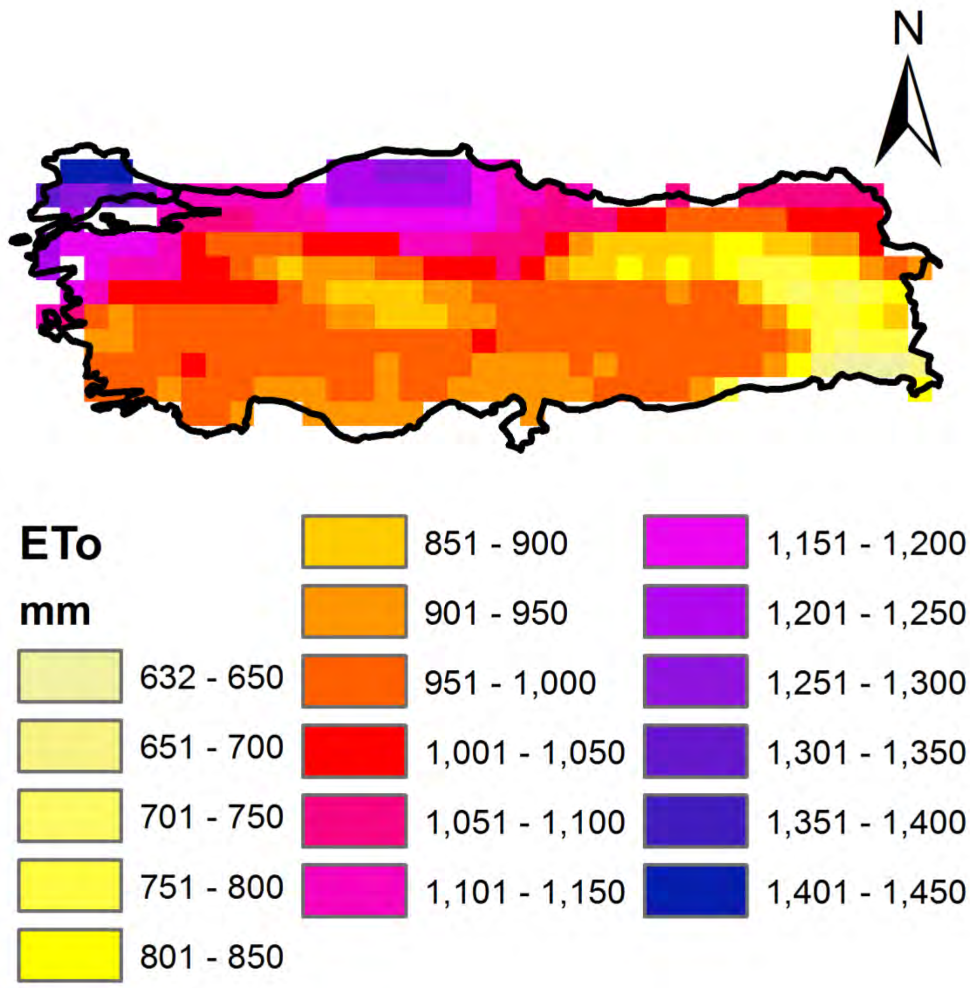
# Spatial Trends and Magnitudes of Climate Variables in Türkiye - Annual




N
Avg T
deg C
3.26 - 4
4.01 - 6
6.01 - 8
8.01 - 10
10.01 - 12
12.01 - 14
14.01 - 16
16.01 - 18
N
Precipitation
mm
332 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 900
901 - 1,000
1,001 - 1,100
1,101 - 1,200
N
Rs
MJ/m2/d
12.8 - 13
13.1 - 13.5
13.6 - 14
14.1 - 14.5
14.6 - 15
15.1 - 15.5
15.6 - 16
16.1 - 16.5
16.6 - 17
17.1 - 17.5
17.6 - 18
18.1 - 18.5
N
Rn
MJ/m2/d
6.81 - 7
7.01 - 7.25
7.26 - 7.5
7.51 - 7.75
7.76 - 8
8.01 - 8.25
8.26 - 8.5
8.51 - 8.75
8.76 - 9
9.01 - 9.25
9.26 - 9.5



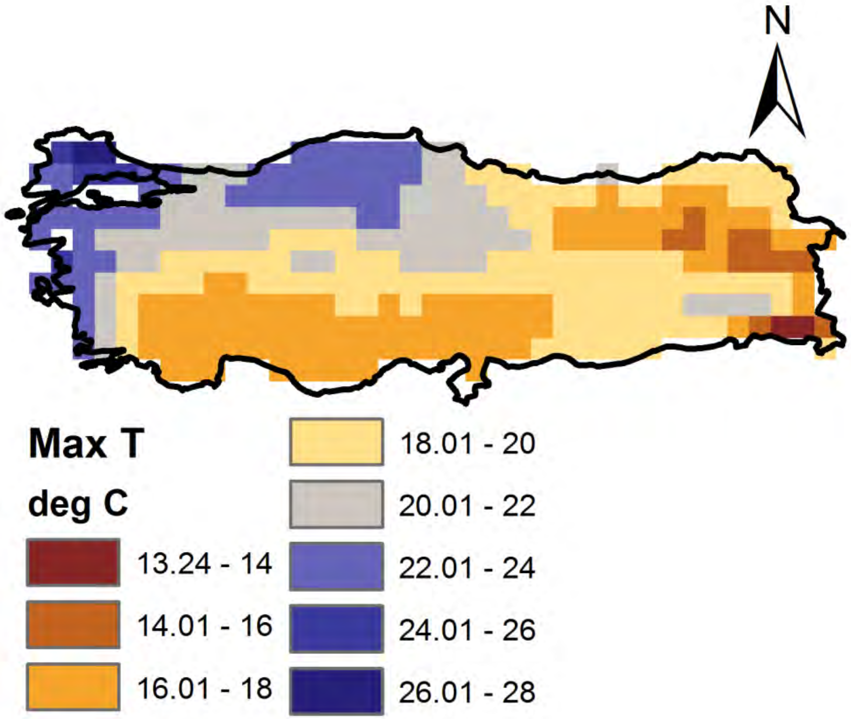
N
RH
%
58.3 - 60
60.1 - 62.5
62.6 - 65
65.1 - 67.5
67.6 - 70
70.1 - 72.5
72.6 - 75
75.1 - 77.5
77.6 - 80
80.1 - 82.5
N
Wind speed at 2m
m/s
0.34 - 0.5
0.51 - 1
1.01 - 1.5
1.51 - 2
2.01 - 2.5
2.51 - 3
3.01 - 3.5
3.51 - 4
4.01 - 4.5
4.51 - 5
5.01 - 5.5
N
ea
kPa
0.57 - 0.6
0.61 - 0.7
0.71 - 0.8
0.81 - 0.9
0.91 - 1
1.01 - 1.1
1.11 - 1.2
1.21 - 1.3
1.31 - 1.4
1.41 - 1.5
N
VPD
kPa
0.32 - 0.35
0.36 - 0.4
0.41 - 0.45
0.46 - 0.5
0.51 - 0.55
0.56 - 0.6
0.61 - 0.65
0.66 - 0.7
0.71 - 0.75
0.76 - 0.8
0.81 - 0.85
0.86 - 0.9
0.91 - 0.95
0.96 - 1
1.01 - 1.05
1.06 - 1.1
1.11 - 1.15

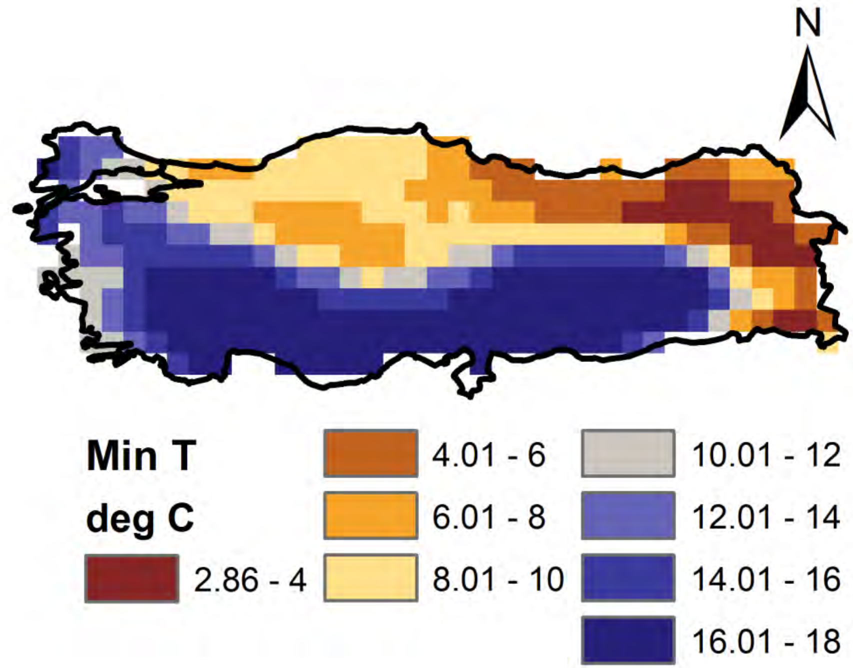


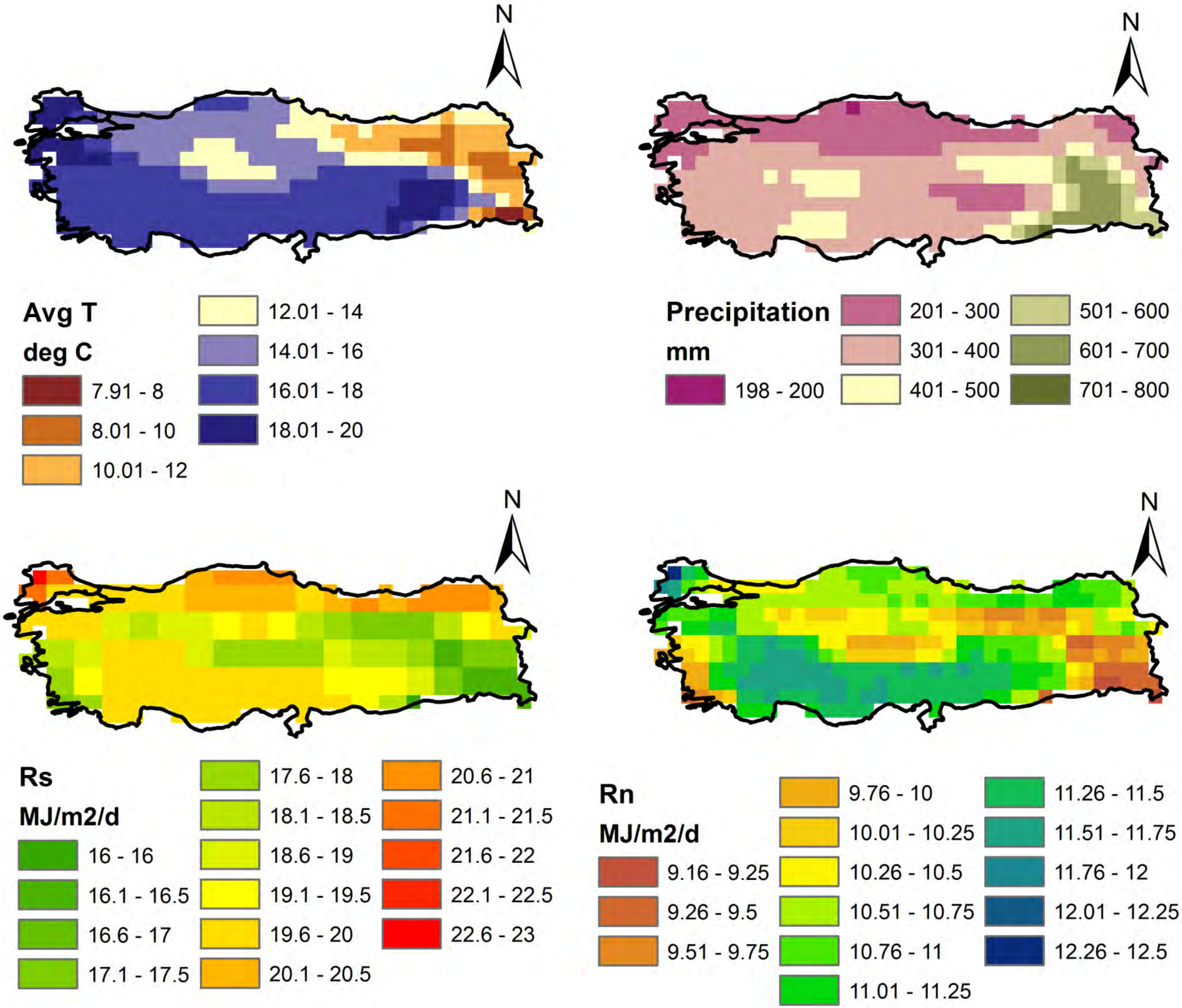

Standardized ASCE-EWRI Penman-Monteith Reference Evapotranspiration

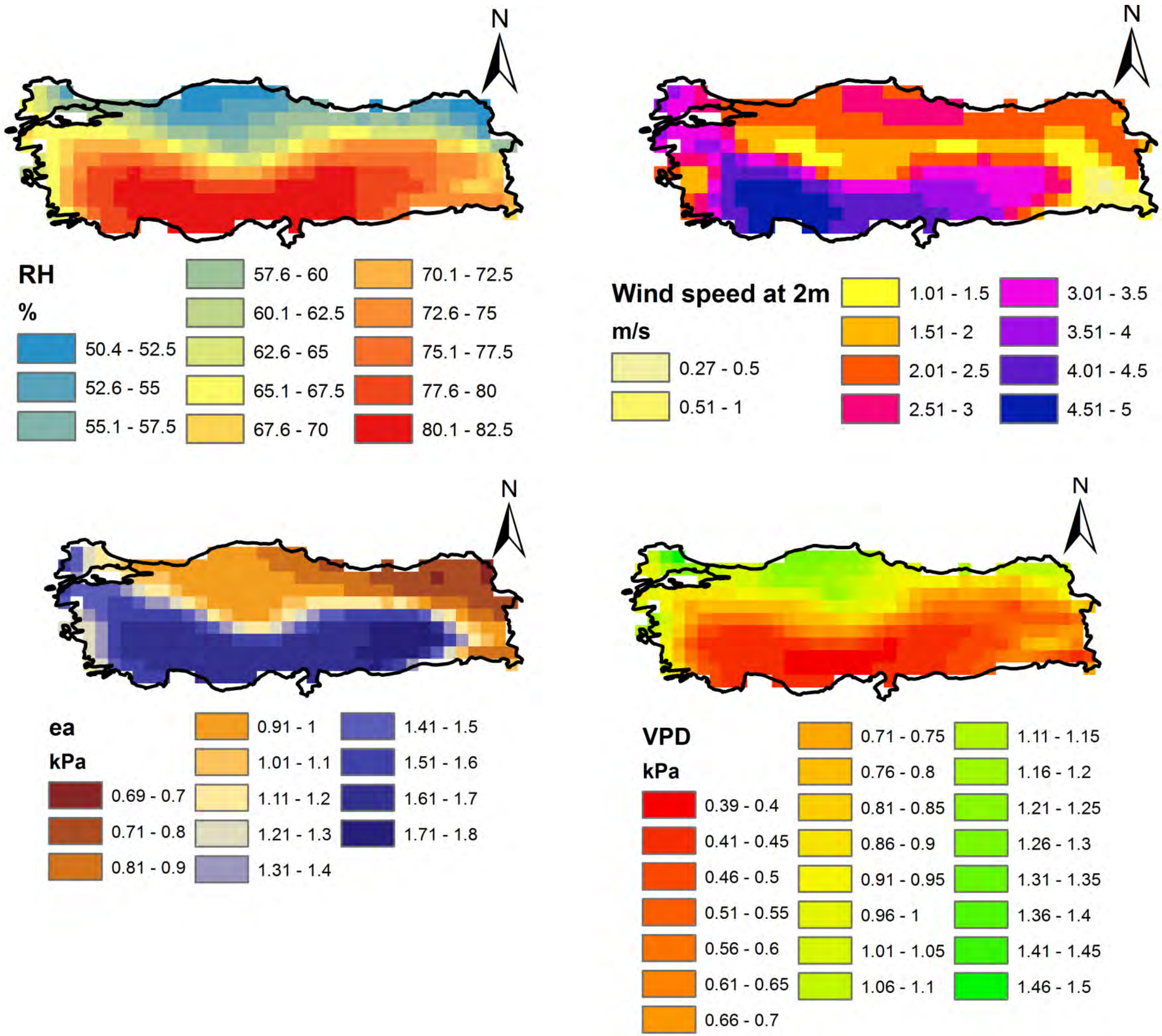
$$ET_o = \frac{0.408\,\Delta(R_n - G) + \Upsilon\left(\frac{900}{T + 273}\right)u_2(e_s - e_a)}{\Delta + \Upsilon(1 + 0.34u_2)}$$

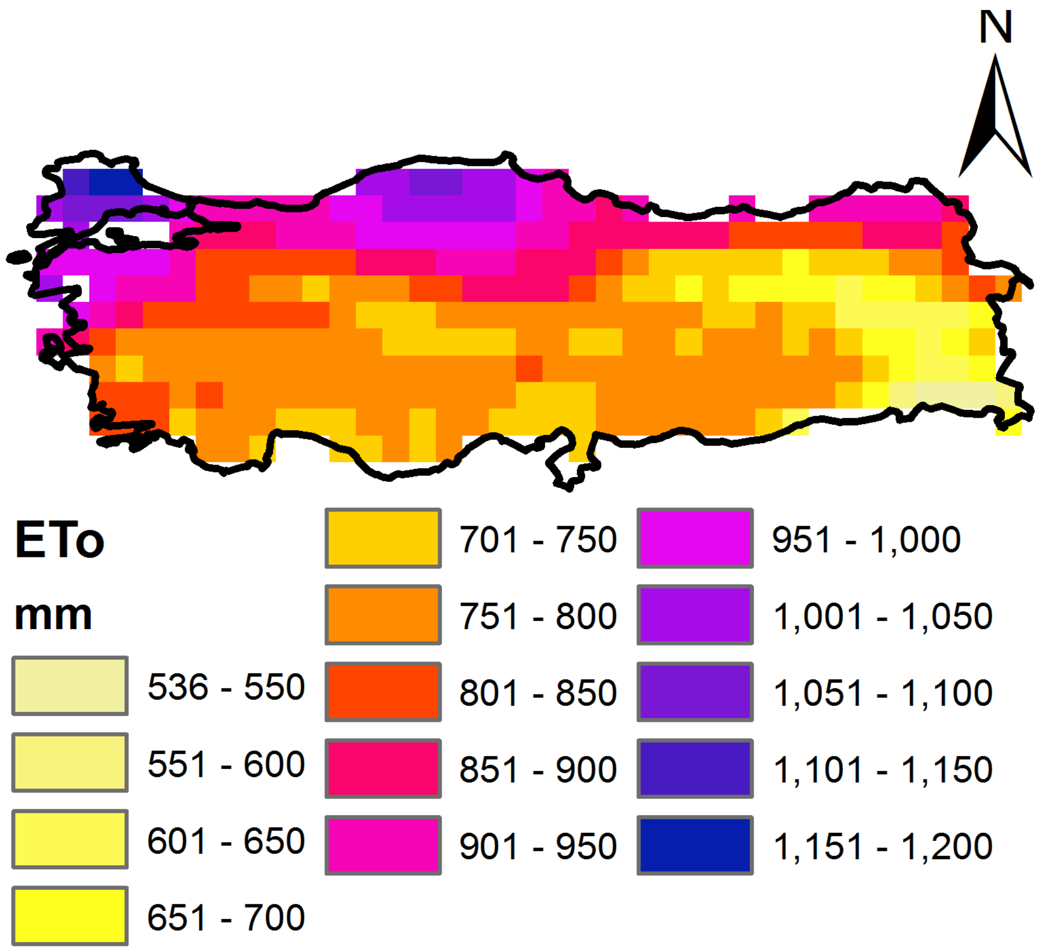
# Spatial Trends and Magnitudes of Climate Variables in Türkiye - Growing Season



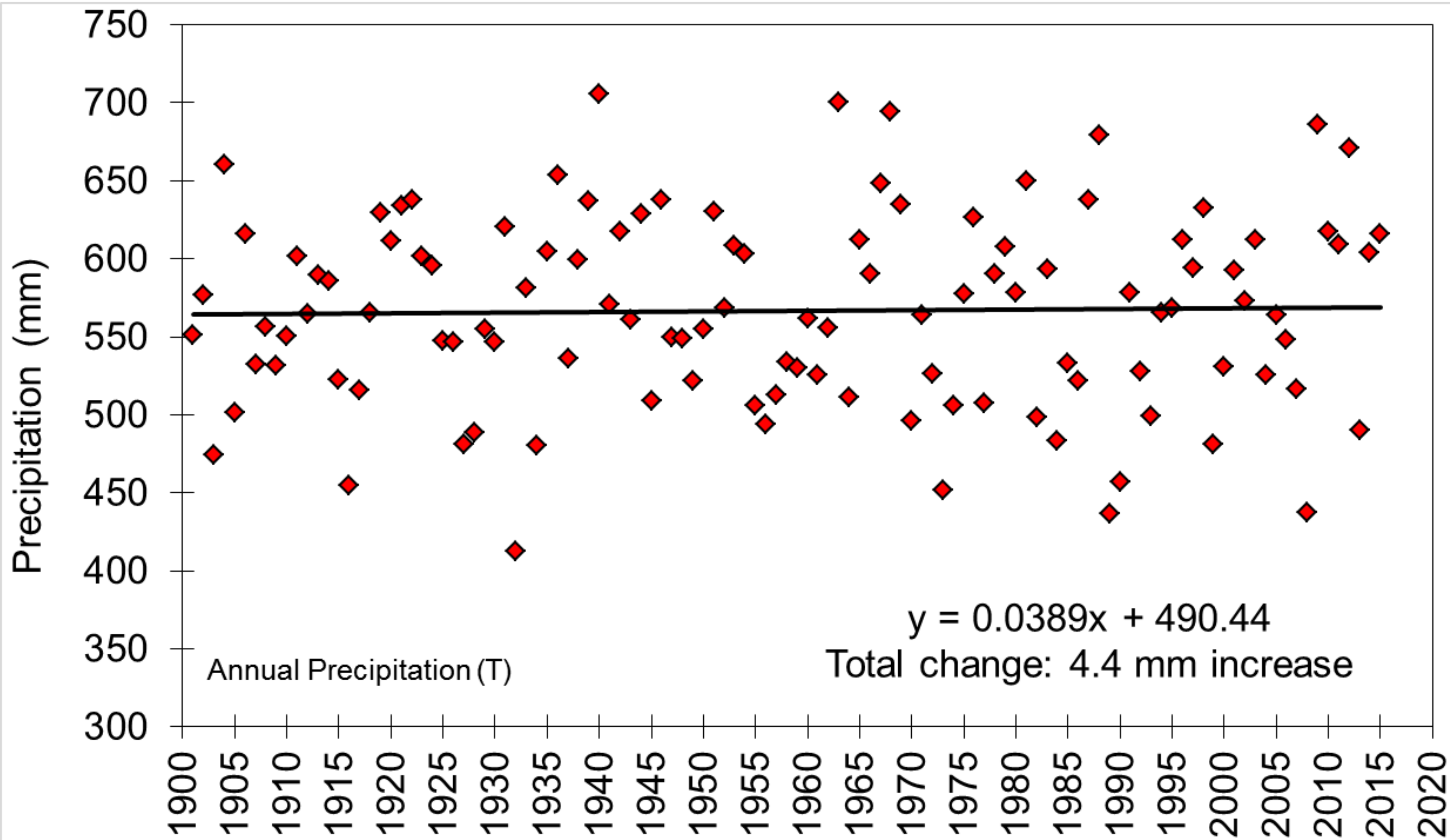




N
Avg T
deg C
7.91 - 8
8.01 - 10
10.01 - 12
12.01 - 14
14.01 - 16
16.01 - 18
18.01 - 20
N
Precipitation
mm
198 - 200
201 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
N
Rs
MJ/m2/d
16 - 16
16.1 - 16.5
16.6 - 17
17.1 - 17.5
17.6 - 18
18.1 - 18.5
18.6 - 19
19.1 - 19.5
19.6 - 20
20.1 - 20.5
20.6 - 21
21.1 - 21.5
21.6 - 22
22.1 - 22.5
22.6 - 23
N
Rn
MJ/m2/d
9.16 - 9.25
9.26 - 9.5
9.51 - 9.75
9.76 - 10
10.01 - 10.25
10.26 - 10.5
10.51 - 10.75
10.76 - 11
11.01 - 11.25
11.26 - 11.5
11.51 - 11.75
11.76 - 12
12.01 - 12.25
12.26 - 12.5

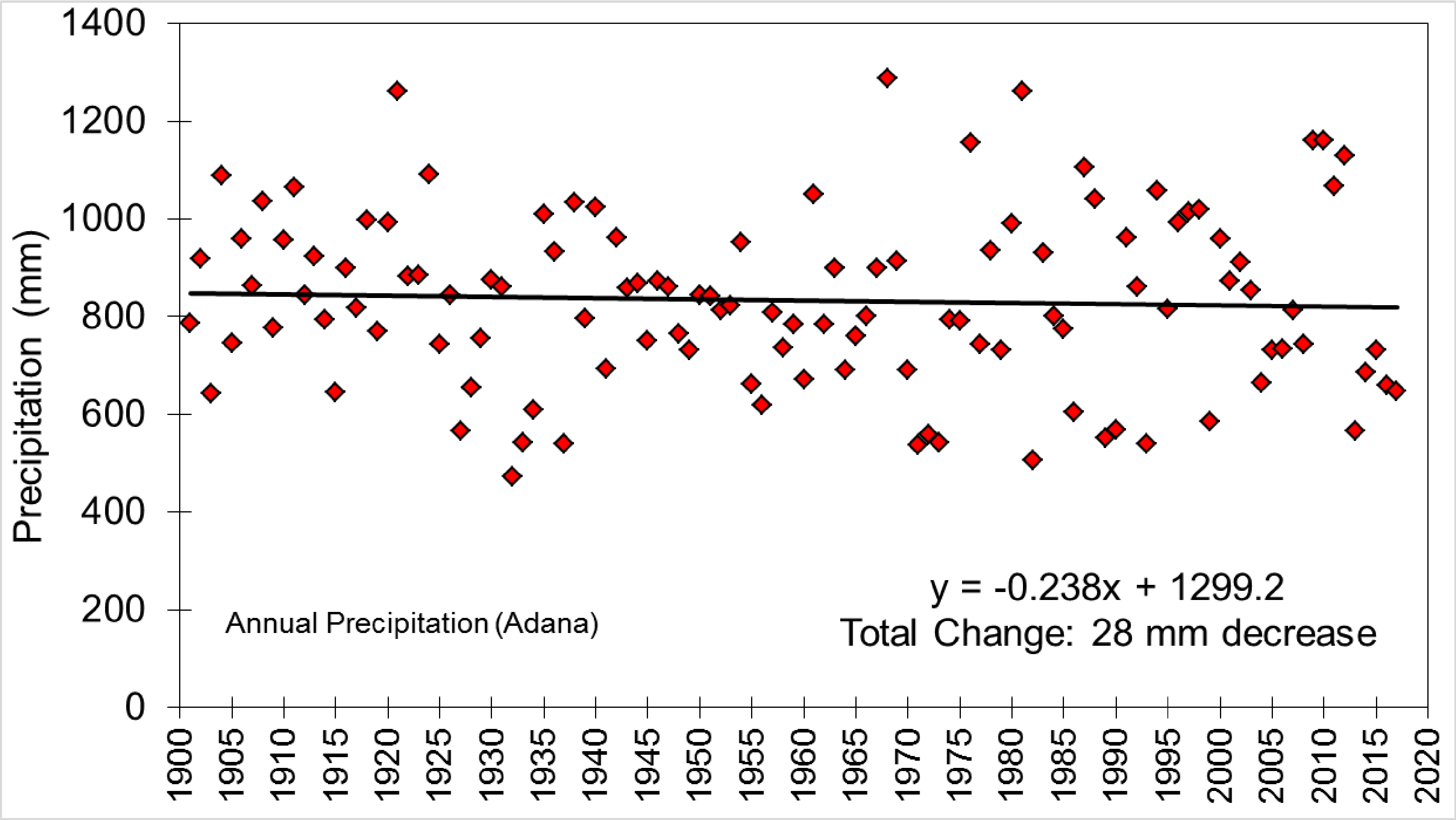

N
RH
%
50.4 - 52.5
52.6 - 55
55.1 - 57.5
57.6 - 60
60.1 - 62.5
62.6 - 65
65.1 - 67.5
67.6 - 70
70.1 - 72.5
72.6 - 75
75.1 - 77.5
77.6 - 80
80.1 - 82.5
N
Wind speed at 2m
m/s
0.27 - 0.5
0.51 - 1
1.01 - 1.5
1.51 - 2
2.01 - 2.5
2.51 - 3
3.01 - 3.5
3.51 - 4
4.01 - 4.5
4.51 - 5
N
ea
kPa
0.69 - 0.7
0.71 - 0.8
0.81 - 0.9
0.91 - 1
1.01 - 1.1
1.11 - 1.2
1.21 - 1.3
1.31 - 1.4
1.41 - 1.5
1.51 - 1.6
1.61 - 1.7
1.71 - 1.8
N
VPD
kPa
0.39 - 0.4
0.41 - 0.45
0.46 - 0.5
0.51 - 0.55
0.56 - 0.6
0.61 - 0.65
0.66 - 0.7
0.71 - 0.75
0.76 - 0.8
0.81 - 0.85
0.86 - 0.9
0.91 - 0.95
0.96 - 1
1.01 - 1.05
1.06 - 1.1
1.11 - 1.15
1.16 - 1.2
1.21 - 1.25
1.26 - 1.3
1.31 - 1.35
1.36 - 1.4
1.41 - 1.45
1.46 - 1.5


N
ETo
mm
536 - 550
551 - 600
601 - 650
651 - 700
701 - 750
751 - 800
801 - 850
851 - 900
901 - 950
951 - 1,000
1,001 - 1,050
1,051 - 1,100
1,101 - 1,150
1,151 - 1,200

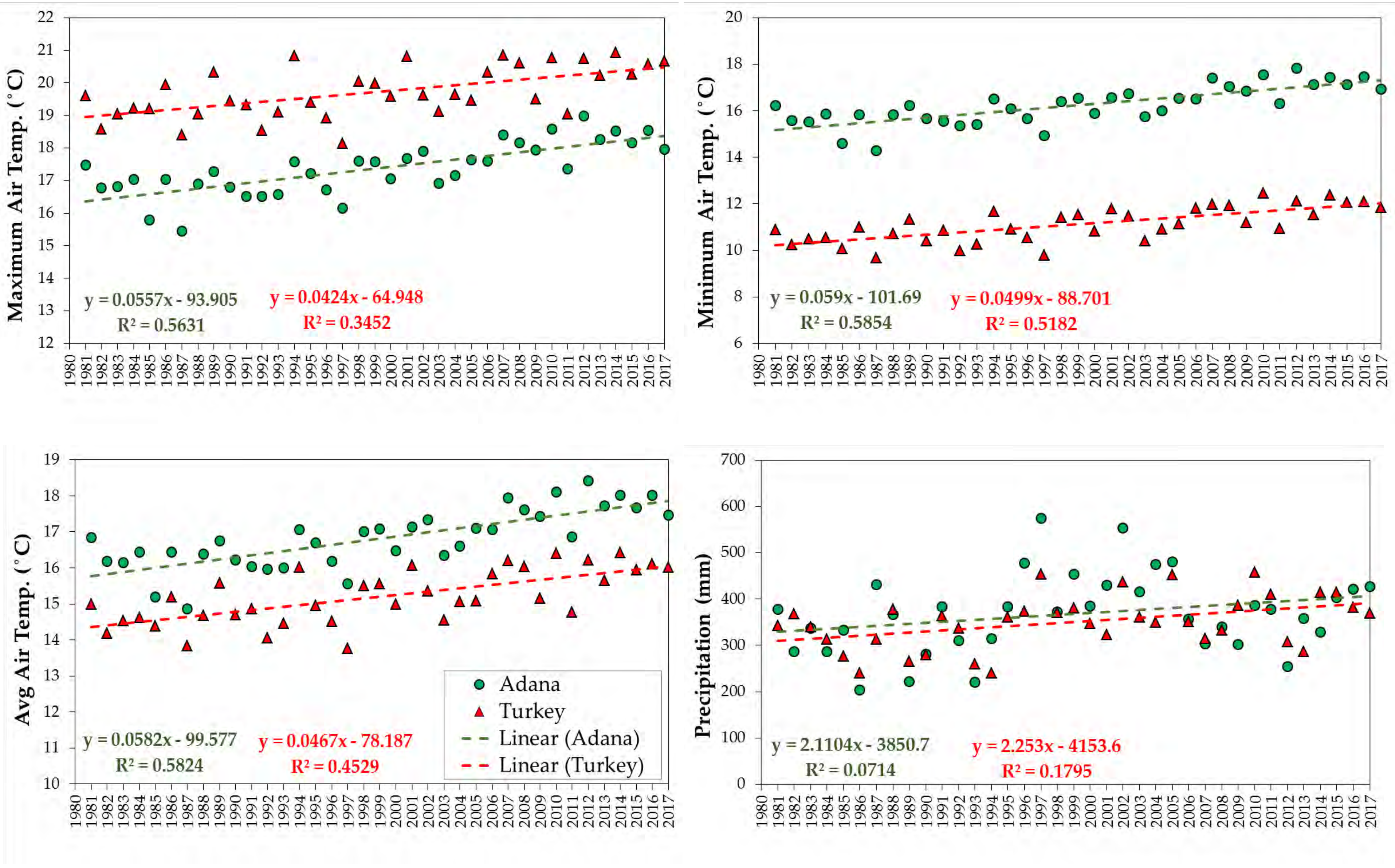
# Annual Precipitation (Türkiye)

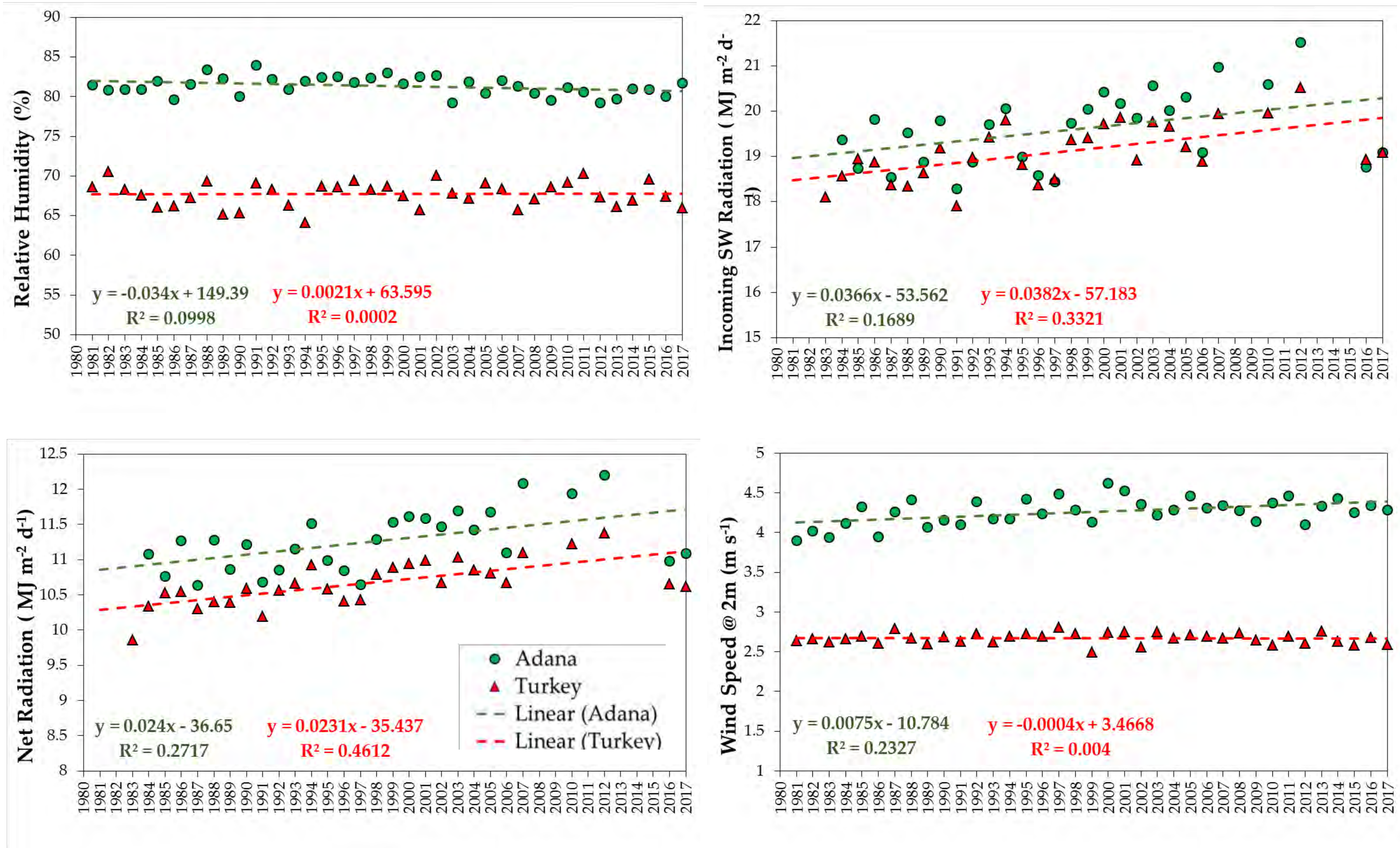


# Annual Precipitation (Adana)

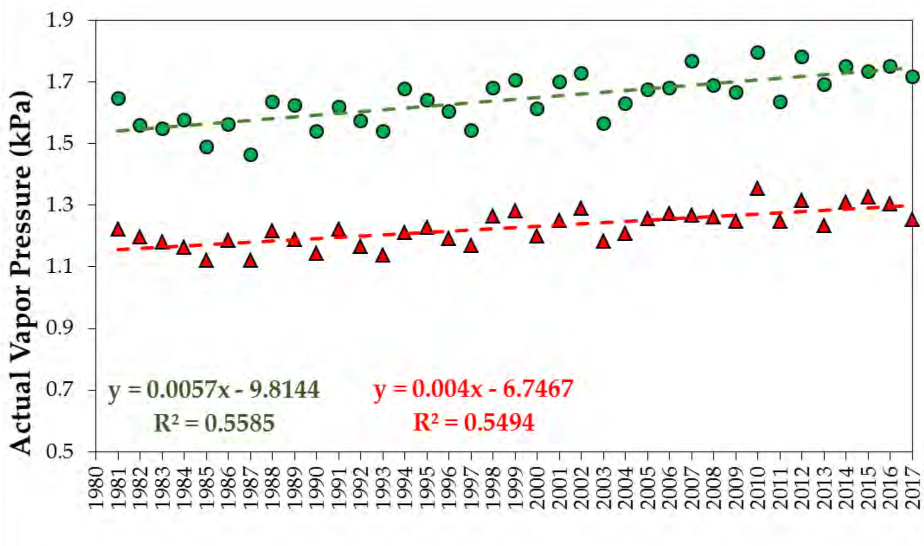


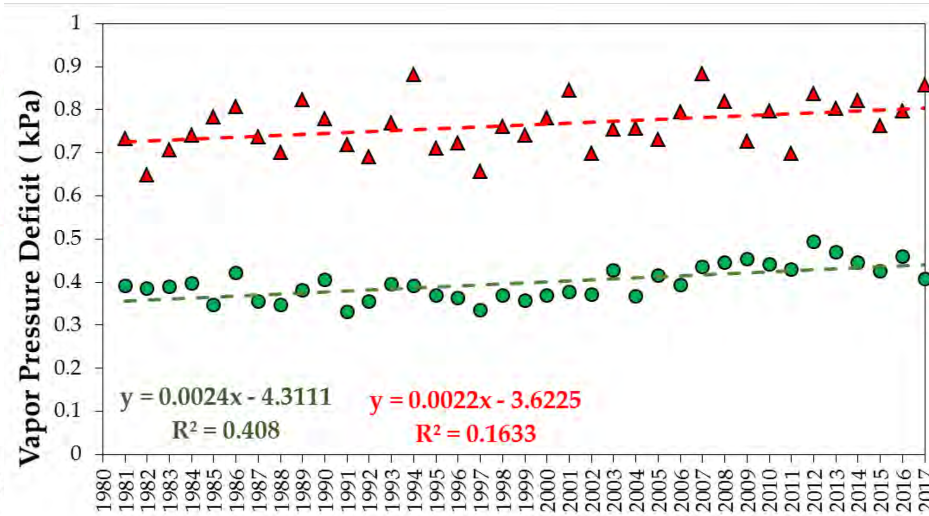
# Temporal trends – Growing Season

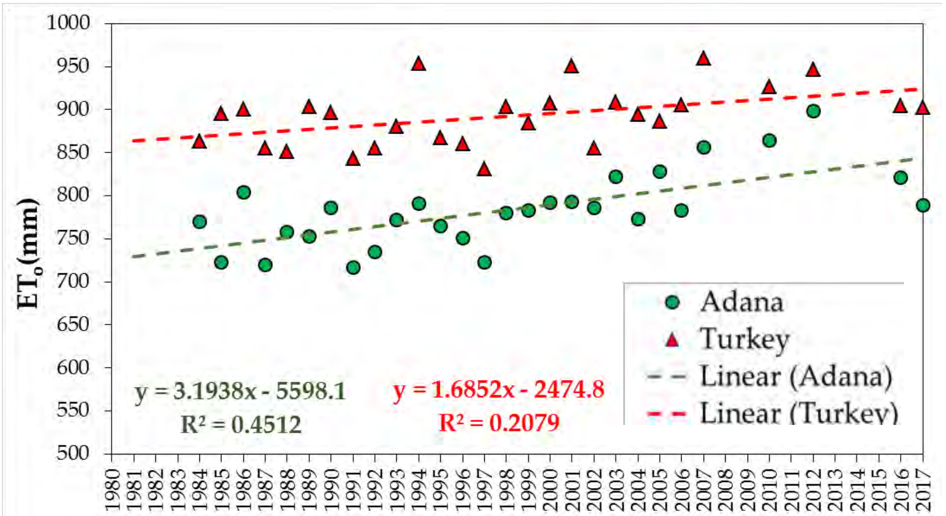




Relative Humidity (%)
y = -0.034x + 149.39
R² = 0.0998
y = 0.0021x + 63.595
R² = 0.0002
Incoming SW Radiation ( MJ m-2 d-1)
y = 0.0366x - 53.562
R² = 0.1689
y = 0.0382x - 57.183
R² = 0.3321
Net Radiation ( MJ m-2 d-1)
y = 0.024x - 36.65
R² = 0.2717
y = 0.0231x - 35.437
R² = 0.4612
Adana
Turkey
Linear (Adana)
Linear (Turkey)
Wind Speed @ 2m (m s-1)
y = 0.0075x - 10.784
R² = 0.2327
y = -0.0004x + 3.4668
R² = 0.004


Actual Vapor Pressure (kPa)
y = 0.0057x - 9.8144
R² = 0.5585
y = 0.004x - 6.7467
R² = 0.5494


Vapor Pressure Deficit ( kPa)
y = 0.0024x - 4.3111
R² = 0.408
y = 0.0022x - 3.6225
R² = 0.1633


ETo(mm)
y = 3.1938x - 5598.1
R² = 0.4512
y = 1.6852x - 2474.8
R² = 0.2079
Adana
Turkey
Linear (Adana)
Linear (Turkey)

| Variable | Region | Time scale | Slope Units | Trend slope | Total change |
|---|---|---|---|---|---|
| *Tavg* | Türkiye | GS | ° C/yr | 0.04672 | 1.7 |
| | | Ann | ° C/yr | 0.04030 | 1.5 |
| | Adana | GS | ° C/yr | 0.05823 | 2.2 |
| | | Ann | ° C/yr | 0.05232 | 1.9 |
| *Tmax* | Türkiye | GS | ° C/yr | 0.04236 | 1.6 |
| | | Ann | ° C/yr | 0.03935 | 1.5 |
| | Adana | GS | ° C/yr | 0.05566 | 2.1 |
| | | Ann | ° C/yr | 0.04988 | 1.8 |
| *Tmin* | Türkiye | GS | ° C/yr | 0.04993 | 1.8 |
| | | Ann | ° C/yr | 0.04146 | 1.5 |
| | Adana | GS | ° C/yr | 0.05900 | 2.2 |
| | | Ann | ° C/yr | 0.05378 | 2.0 |
| *Precipitation* | Türkiye | GS | mm/yr | 2.25299 | 83.4 |
| | | Ann | mm/yr | 1.72037 | 63.7 |
| | Adana | GS | mm/yr | 2.11041 | 78.1 |
| | | Ann | mm/yr | 1.15675 | 42.8 |
| *RH* | Türkiye | GS | %/yr | 0.00207 | 0.1 |
| | | Ann | %/yr | -0.01431 | -0.5 |
| | Adana | GS | %/yr | -0.03404 | -1.3 |
| | | Ann | %/yr | -0.01809 | -0.7 |
| *Rs* | Türkiye | GS | $MJ/m^2/yr$ | 0.03819 | 1.4 |
| | | Ann | $MJ/m^2/yr$ | 0.02621 | 1.0 |
| | Adana | GS | $MJ/m^2/yr$ | 0.03661 | 1.4 |
| | | Ann | $MJ/m^2/yr$ | 0.02670 | 1.0 |
| *Rn* | Türkiye | GS | $MJ/m^2/yr$ | 0.02308 | 0.9 |
| | | Ann | $MJ/m^2/yr$ | 0.01390 | 0.5 |
| | Adana | GS | $MJ/m^2/yr$ | 0.02398 | 0.9 |
| | | Ann | $MJ/m^2/yr$ | 0.01638 | 0.6 |

| Variable | Region | Time scale | Slope Units | Trend slope | Total change |
|---|---|---|---|---|---|
| ***WS*** | **Türkiye** | **GS** | **m/s/yr** | -0.00040 | -0.01 |
| | | **Ann** | **m/s/yr** | -0.00145 | -0.05 |
| | **Adana** | **GS** | **m/s/yr** | 0.00753 | 0.28 |
| | | **Ann** | **m/s/yr** | 0.00459 | 0.17 |
| ***ea*** | **Türkiye** | **GS** | **kPa/yr** | 0.00399 | 0.15 |
| | | **Ann** | **kPa/yr** | 0.00303 | 0.11 |
| | **Adana** | **GS** | **kPa/yr** | 0.00573 | 0.21 |
| | | **Ann** | **kPa/yr** | 0.00472 | 0.17 |
| ***VPD*** | **Türkiye** | **GS** | **kPa/yr** | 0.00219 | 0.08 |
| | | **Ann** | **kPa/yr** | 0.00186 | 0.07 |
| | **Adana** | **GS** | **kPa/yr** | 0.00236 | 0.09 |
| | | **Ann** | **kPa/yr** | 0.00174 | 0.06 |
| ***ETo*** | **Türkiye** | **GS** | **mm/yr** | 1.68525 | 62.35 |
| | | **Ann** | **mm/yr** | 2.30130 | 85.15 |
| | **Adana** | **GS** | **mm/yr** | 3.19376 | 118.17 |
| | | **Ann** | **mm/yr** | 3.59372 | 132.97 |

What can be done to mitigate potentially negative impacts of change in climate variables on agricultural productivity and water resources?

# Well… We have a lot of work ahead!

- We must start and/or expedite ***RESEARCH AND SCIENTIFIC DISCOVERIES.***

- Whether it is "man-made" or "natural occurrence," climate variables are changing and they are having significant impacts on our agro-ecosystems. This message must be communicated through good quality science and research data and information.

- Potential changes in climate variables must be quantified and studied for all major agriculturally important regions with finer resolution.

- Crop water use (evapotranspiration) and crop response to water and other environmental factors must be quantified for most, if not all, cropping systems.

- Climate variables must be measured with good quality weather stations/instrumentation with finer resolutions and spatio-temporally.

- Agricultural impacts of magnitude and trends if change in climate variables must be economically quantified.

- Impact(s) of climate variables on water resources must be quantified with finer resolutions. and spatio-temporally.

- Effective agricultural practices that can aid in encountering some of the negative impacts of change in climate variables must be researched, demonstrated and education programs must be developed to enable adoption of these strategies in production fields.

- Technology implementation in agriculture and natural resources and water resources must be accomplished. It is an extremely difficult task, but not impossible.

Some examples from Irmak Research Programs:

**Fully automated VRI anf VRF state-of-the-art irrigation system.**

## *Lateral (linear)-move sprinkler irrigation technology for variable rate irrigation and fertigation*




MADE IN THE U.S.A

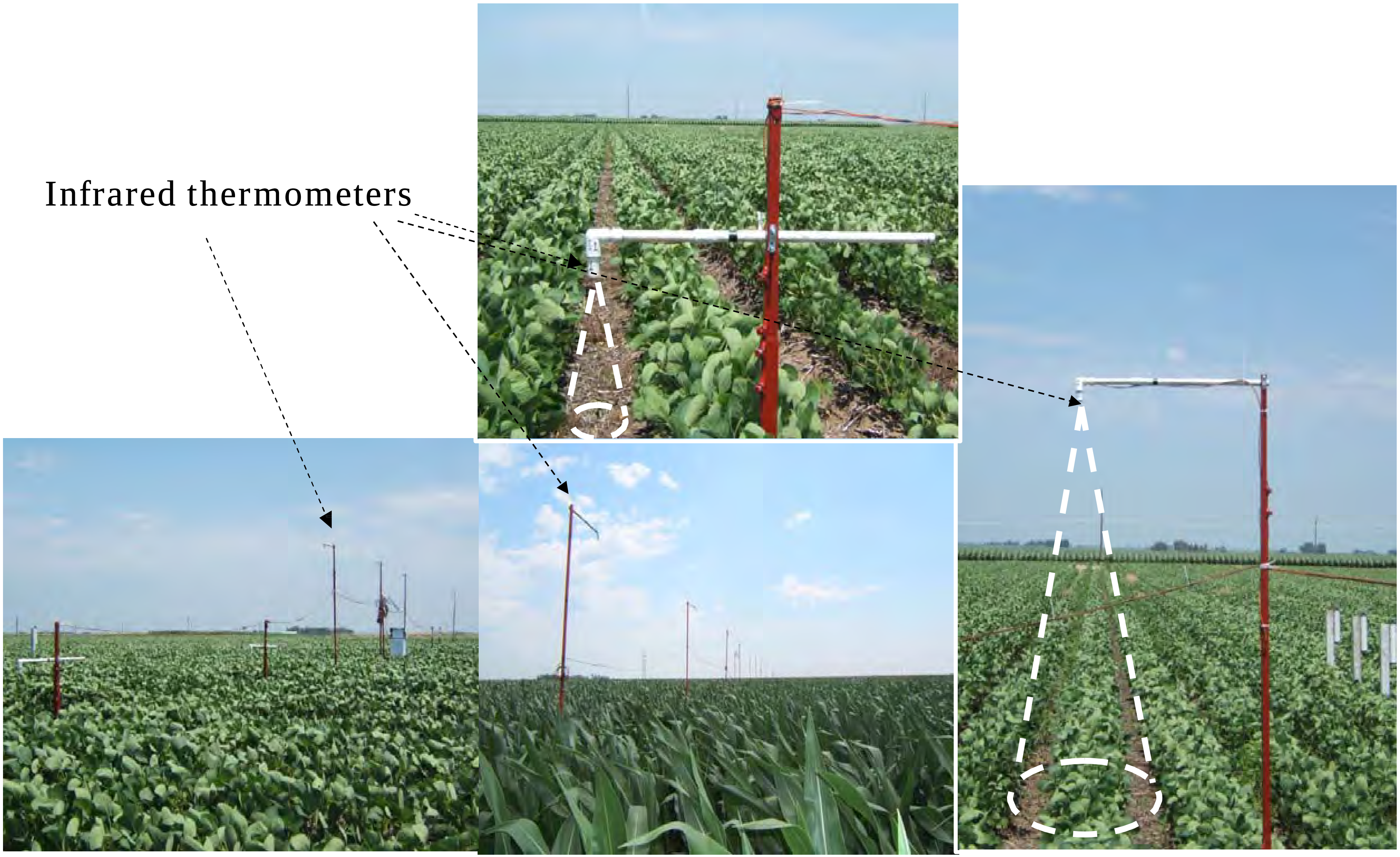

IN


S250


WATER METERS
TEST CERTIFICATE


CAMPBELL SCIENTIFIC
SDM-IO16

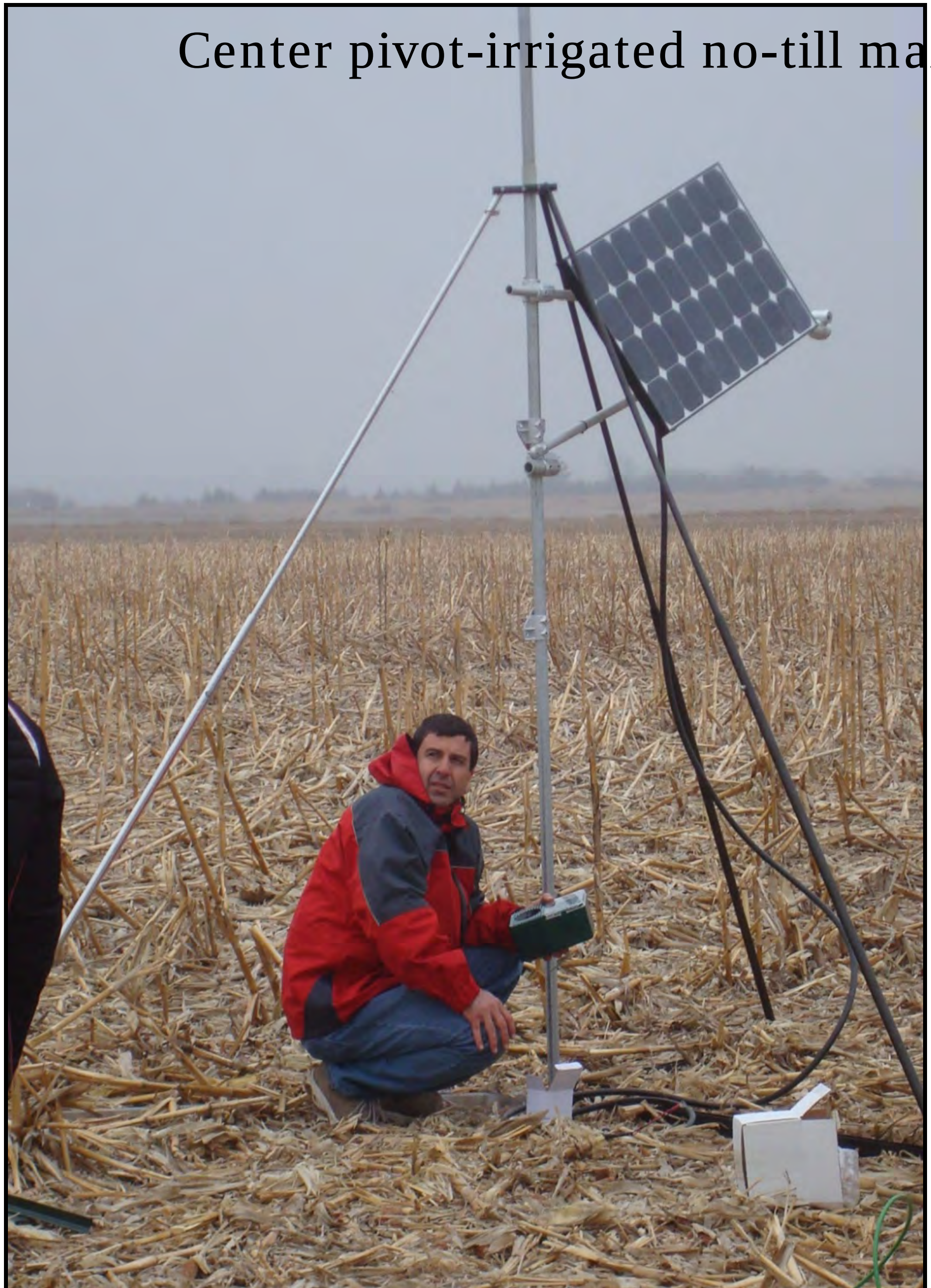
# First PMDI-Equipped Center Pivot – Irmak Research Laboratory

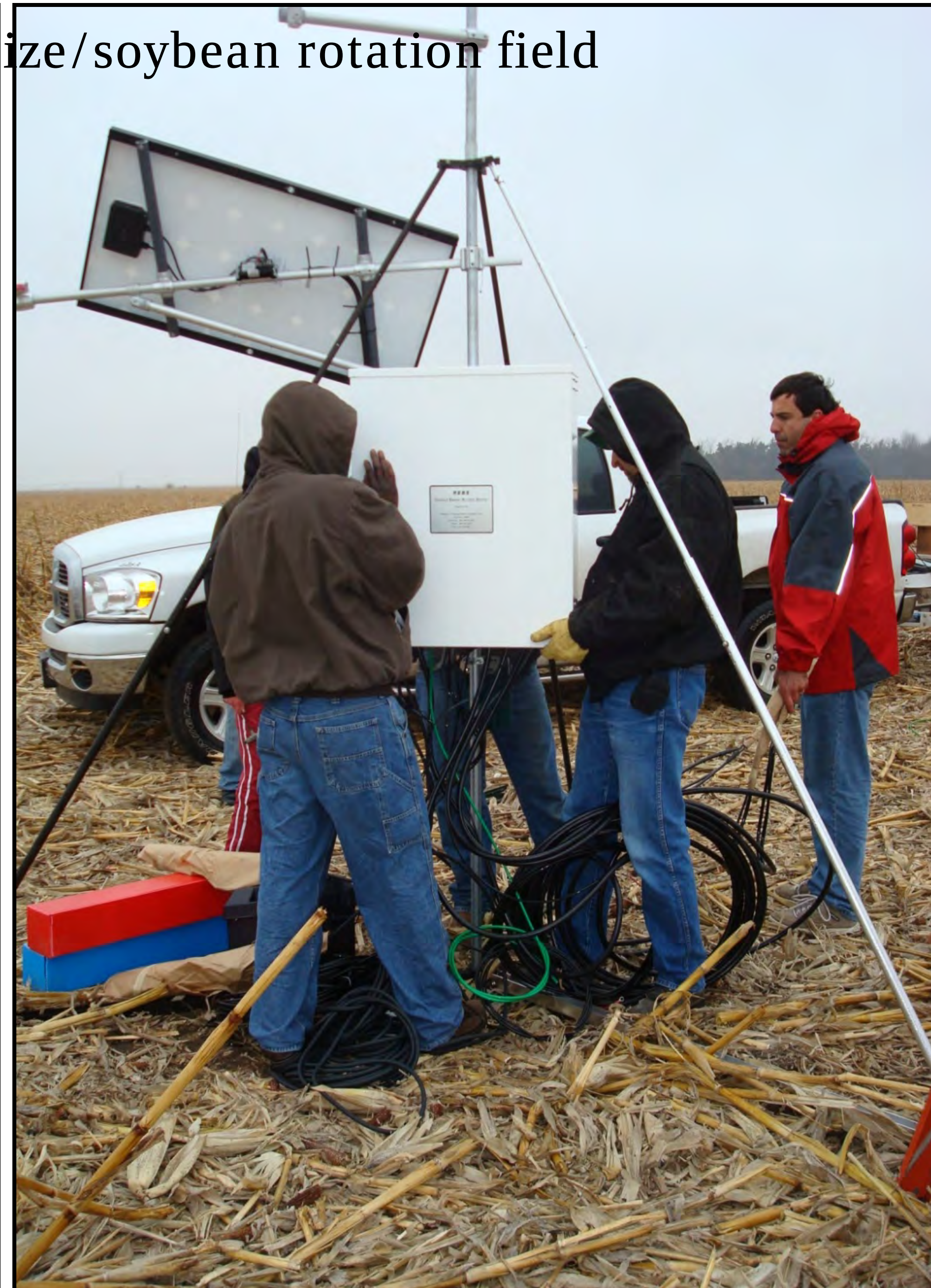

Infrared thermometers

# Center pivot-irrigated disk-tilled maize/soybean rotation

Center pivot-irrigated no-till maize/soybean rotation

Center pivot-irrigated no-till maize/soybean rotation field



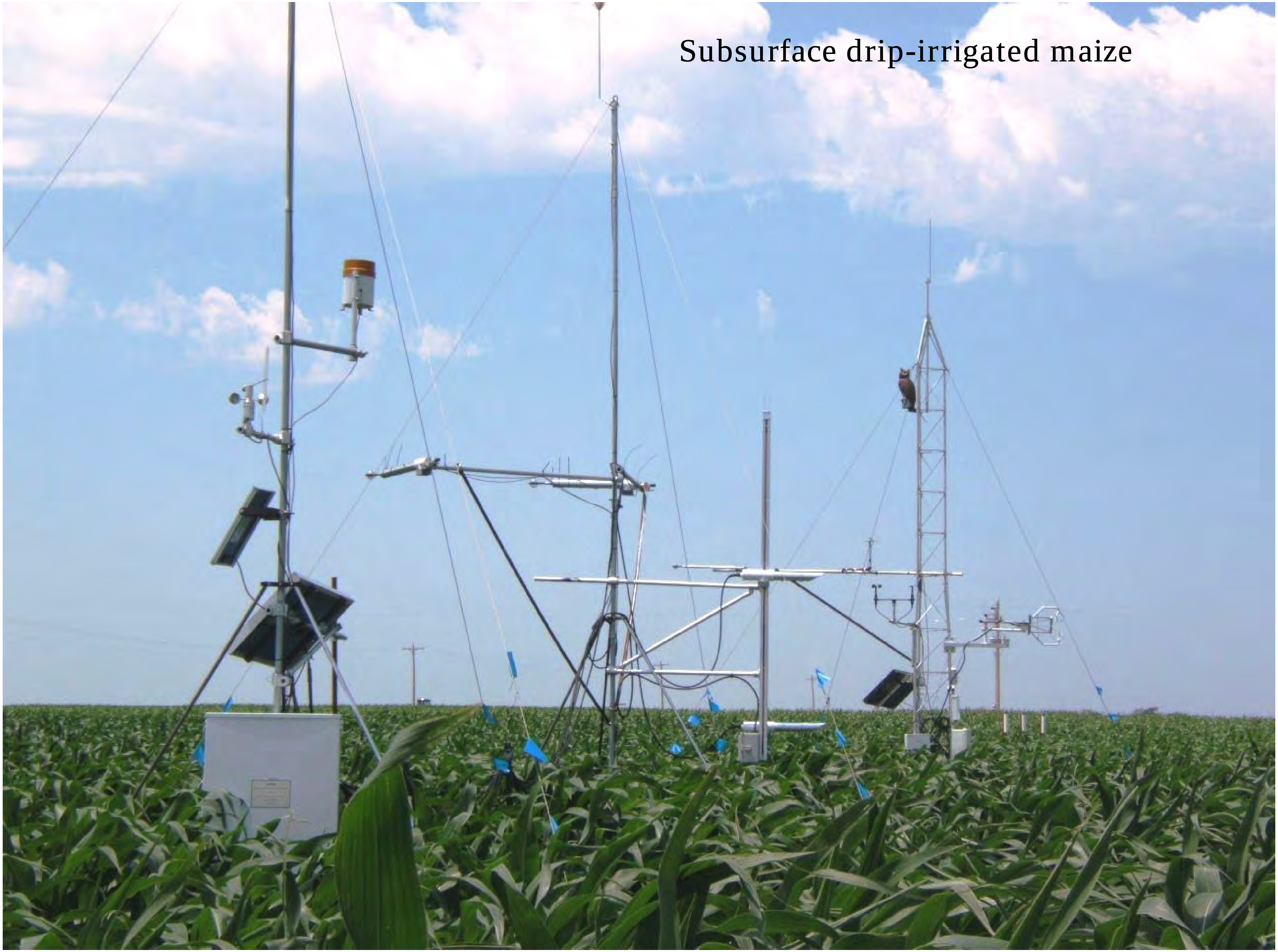



Ford
16167

Crop water use (evapotranspiration) and crop response to water and other environmental factors must be quantified for most, if not all, cropping systems.

## Example:

## Nebraska Water and Energy Flux Measurement, Modeling and Research Network (NEBFLUX)


Subsurface drip-irrigated maize


Center pivot-irrigated grassland


Rainfed grassland


Rainfed winter wheat
BREBS
tower

Subsurface drip-irrigated winter wheat

Phragmites-dominated cottonwood and peach leaf willow riparian community

Subsurface drip-irrigated soybean

Center pivot-irrigated alfalfa

# Subsurface drip- and center pivot-irrigated grain sorghum

# Center pivot-irrigated popcorn


Rainfed Switchgrass

# Rainfed switchgrass

# Surface drip-irrigated vineyard

# Impacts of cover crop on soil quality, soil-water, and energy balance

- Ethiopian Cabbage
- Common Vetch
- Hairy Vetch
- Crimson Clover
- Sudan grass
- Millet
- Radish
- Winter pea
- Rapeseed
- Turnip
- Cereal rye
- Sorghum sudan
- Oats


11/07/2014


11/07/2014

# Center pivot-irrigated Black Turtle Bean

Watermelon water productivity, evapotranspiration, etc.

Sweet maize evapotranspiration,
water productivity, etc.


Nebraska
1500
446A

# Dormant season evaporative losses and energy and water balance

S. Irmak, 01/28/2008

Dormant season evaporative losses and energy and water balance

# Grain Yield, Crop and Basal Evapotranspiration, Production Functions, and Water Productivity Response of Drought-Tolerant and Non-Drought-Tolerant Maize Hybrids under Different Irrigation Levels, Population Densities, and Environments: Part II. In Northeast and South Central Nebraska's Sub-humid and Transition Zone Environments

S. Irmak*, A.T. Mohammed, and W.L. Kranz

The authors are: **Suat Irmak, ASABE Member,** Distinguished Professor, University of Nebraska-Lincoln (UNL); **Ali T. Mohammed, ASABE Member,** Graduate Research Assistant, UNL; **William L. Kranz, ASABE Member,** Professor, UNL. ***Corresponding author: Suat Irmak**, University of Nebraska-Lincoln, 239 L.W. Chase Hall, Lincoln, NE 68583-0726, phone: (402) 472-4865, fax: (402) 472-6338, e-mail: sirmak2@unl.edu.



***Abstract**. Information and data on newer drought-tolerant maize hybrid response to water in different climates are extremely scarce. This research quantified the performance of non-drought-tolerant (NDT) (H1) and drought-tolerant (DT) (H2, H3, and H4) maize (Zea mays L.) hybrids response to grain yield, crop evapotranspiration ($ET_c$), basal evapotranspiration ($ET_b$), $ET_c$-yield production functions (ETYPF),*

The message must be communicated through good quality science and research data and information to the citizens to help them to make better informed farming decisions through adoption of technologies and sound strategies.

# EXAMPLE:
# NEBRASKA AGRICULTURAL WATER MANAGEMENT NETWORK (NAWMN):

## INTEGRATING RESEARCH AND EXTENSION/OUTREACH FOR WATER AND ENERGY CONSERVATION AND ENHANCING AGRICULTURAL PRODUCTION EFFICIENCY

NAWMN

Nebraska Agricultural Water Management Network

# Challenges/Need Assessment/Baselines

- Maximizing the net benefits of irrigated and rainfed/dryland crop production while reducing potential negative environmental impact(s) through appropriately designed agricultural water management programs is needed in Nebraska, USA, and around the world because many areas are involved in management and policy changes to conserve water and energy resources used in agro-ecosystem productivity.

- Growers are being challenged to practice conservation methods and use water resources more efficiently and reduce unbeneficial use of water resources while meeting crop water requirements for maximum net return.

- Technology implementation in agricultural water management in Nebraska was one of the worse in the nation in 2003-2004.

# NAWMN specific goals

- Transfer high quality research information on soil water status and crop water use measurements to farmers and their advisors through a series of demonstration projects established in growers fields to enhance productivity.

- Foster adoption of newer irrigation water management technologies to help farmers to increase water use efficiency, save water, reduce energy consumption, and protect environmental services.

- Enhance communication and enable idea and information exchange between growers, crop consultants, academics, NRDs, NRCS, DNR, irrigation districts, etc.

- Educate Nebraska youth and Ag. Teachers on soil and water resources engineering and science and advanced/next generation technologies.

# NAWMN specific goals

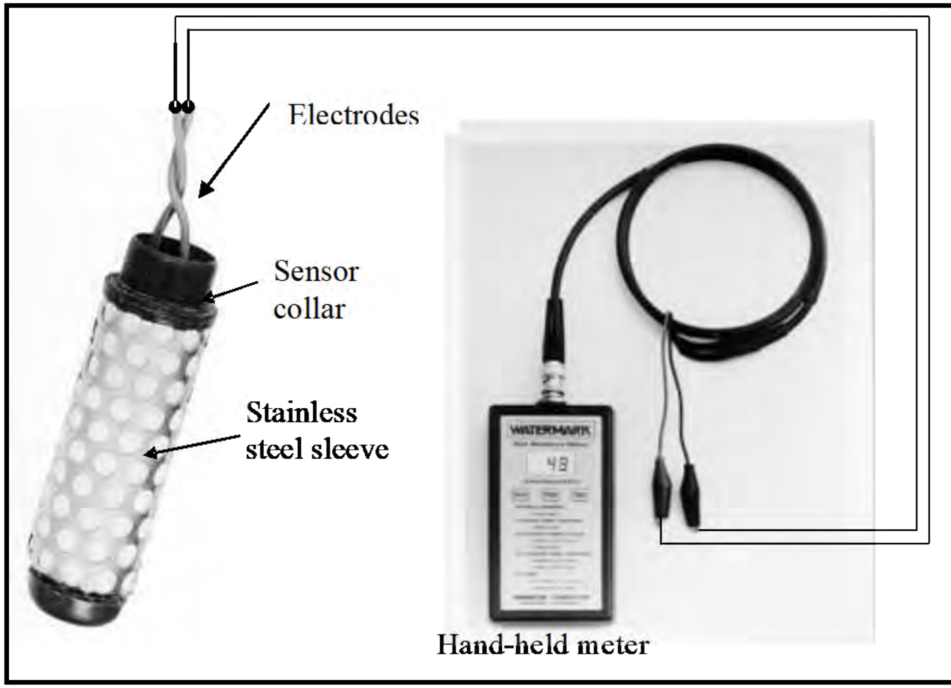
- Develop next generation water, soil, and crop management tools to continue technology implementation in agriculture and be recognized as one of the best in agricultural research and education in the nation/world.

- Quantify short- and long-term and *large scale measurable impacts* in terms of environmental and economic impacts of the Network

- Enhance scientific literacy of growers/agricultural professionals.

# Water management technologies implemented

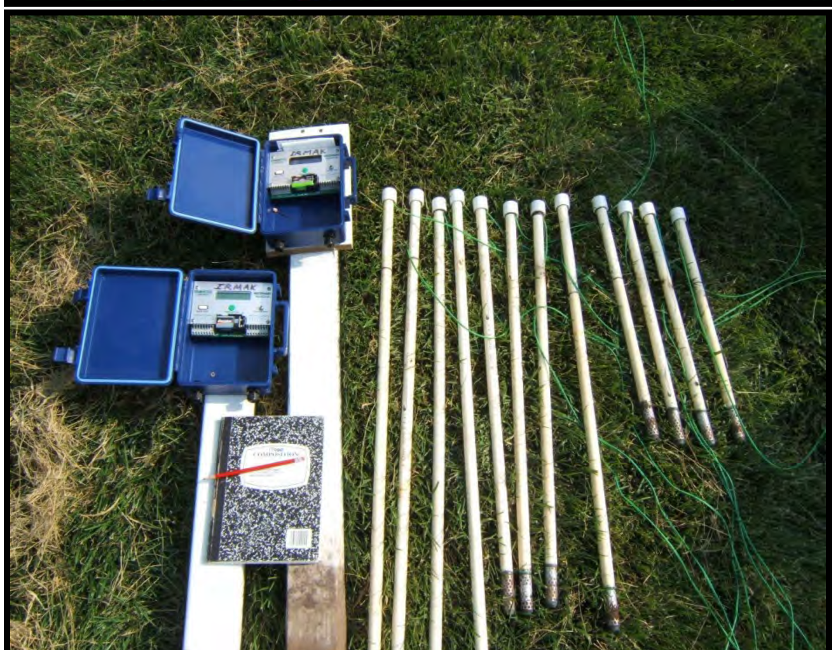
# Granular matrix sensors to measure soil-water status



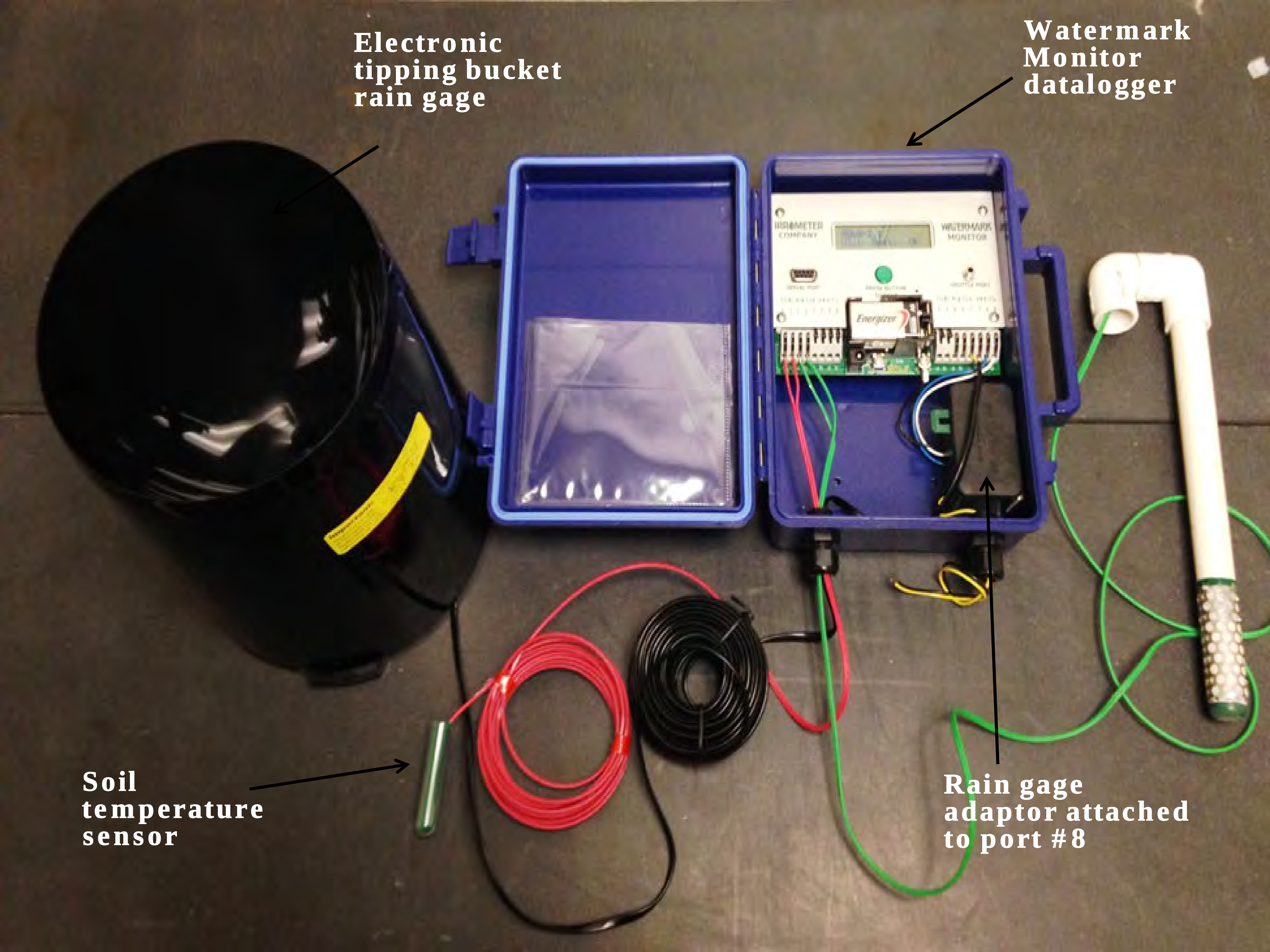


IRROMETER
COMPANY
WATERMARK
MONITOR
SERIAL PORT
PRESS BUTTON
TO READ
SHUTTLE PORT
SENSORS
SENSORS
Energizer

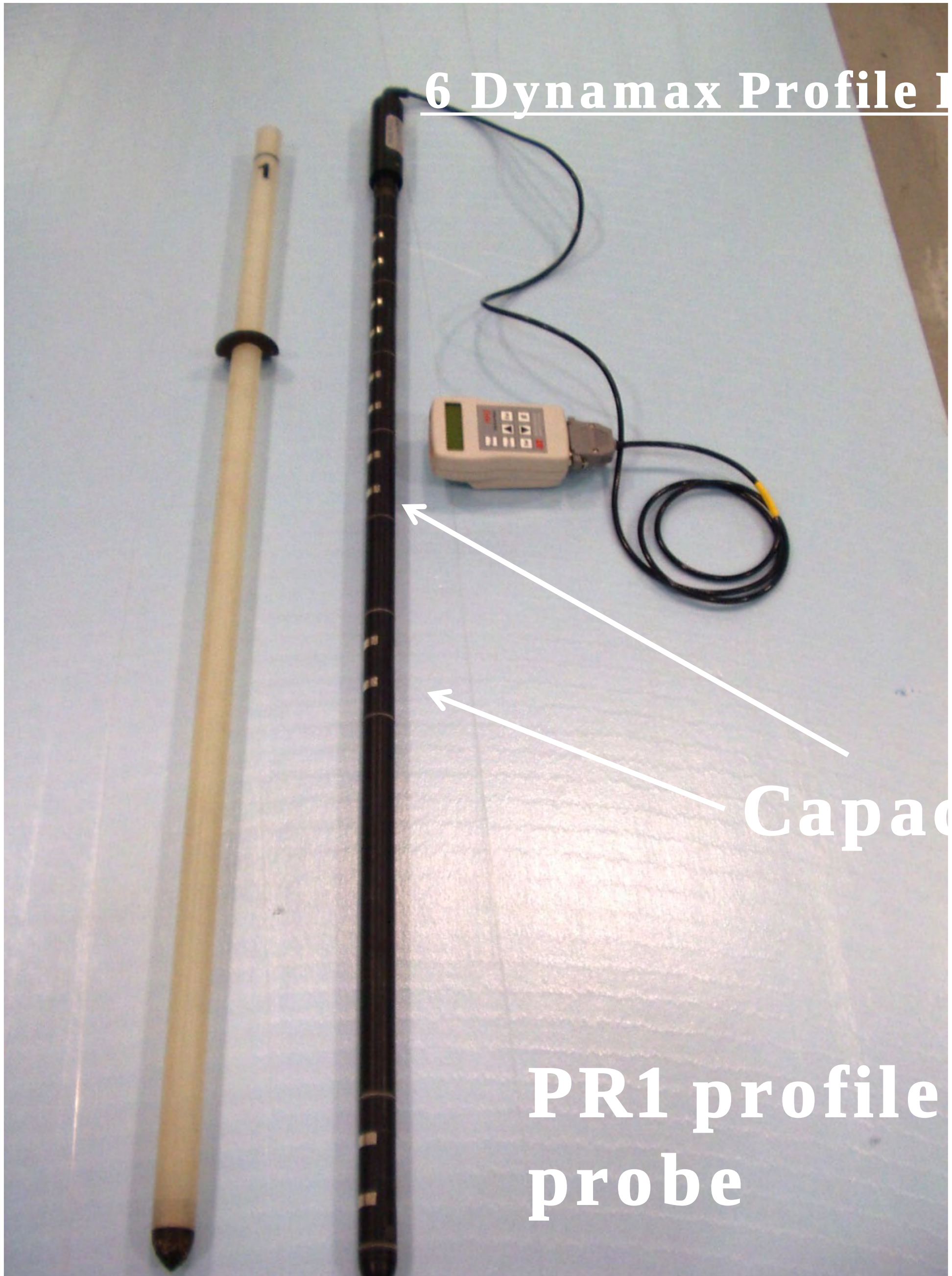

WATERMARK
MONITOR
IRROMETER COMPANY, INC.
RIVERSIDE, CA




WATERMARK

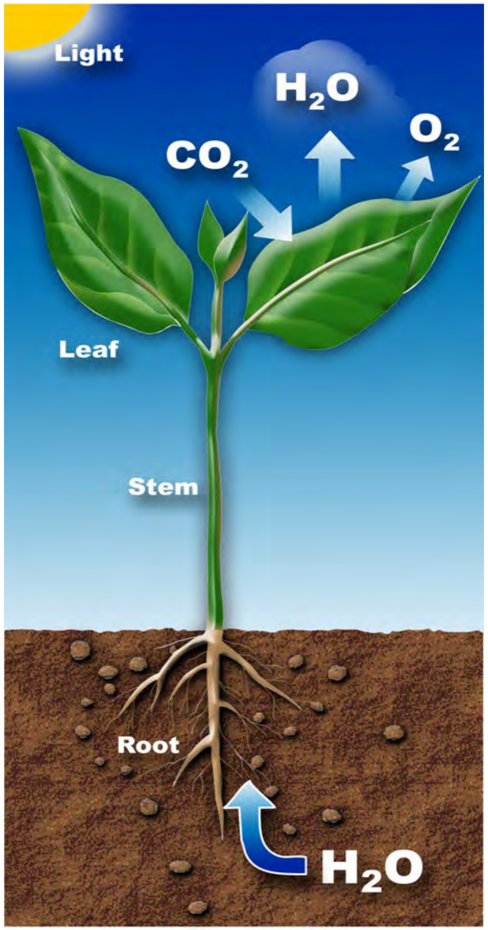

Electronic tipping bucket rain gage
Watermark Monitor datalogger
Soil temperature sensor
Rain gage adaptor attached to port #8

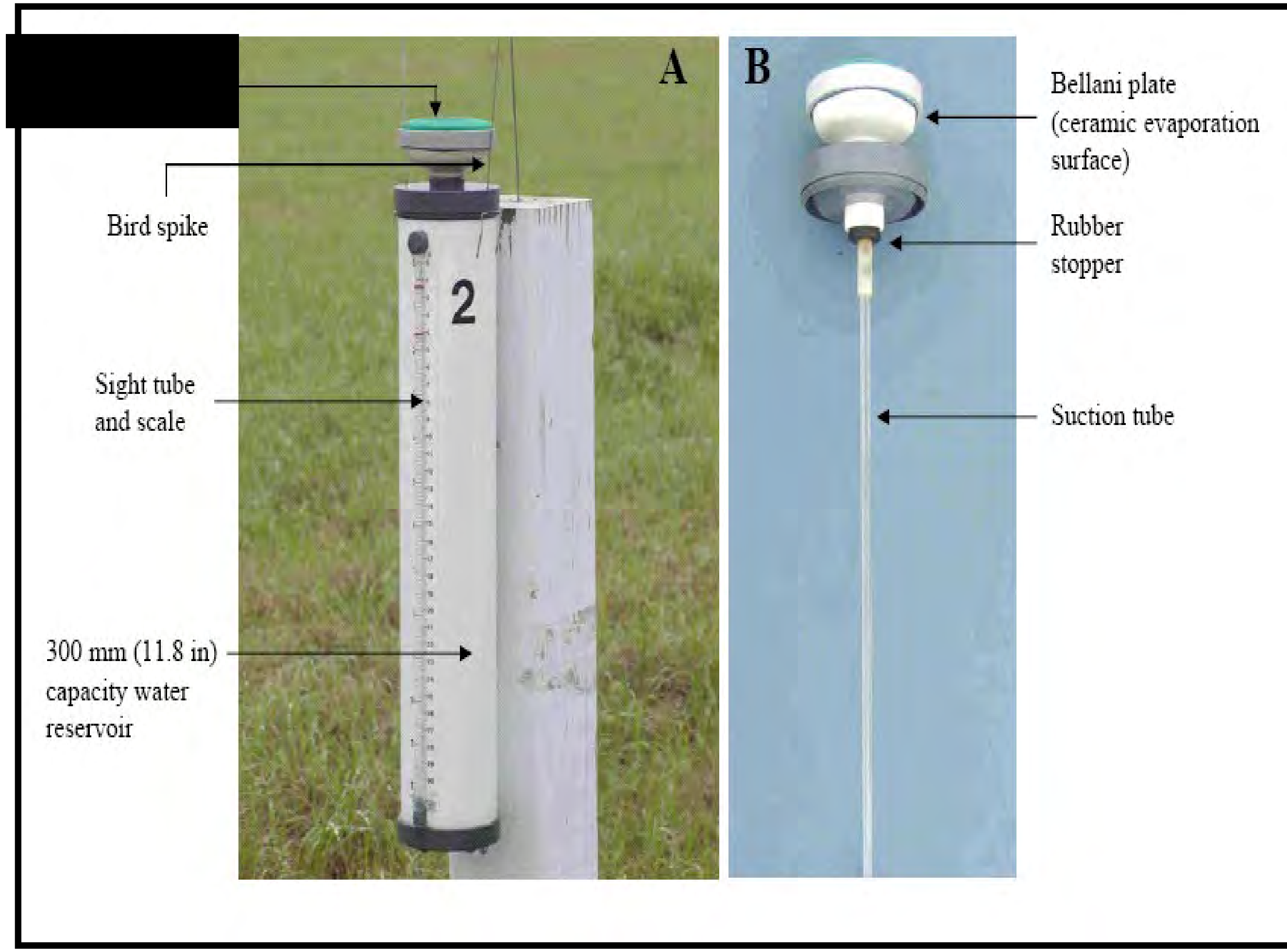
# Constantly searching for new tools/technologies


6 Dynamax Profile
Capac
PR1 profile
probe


JOHN DEERE
CropSense

# ATMOMETER (ETgauge) to monitor local crop water use






Extensive on-farm demonstration projects (over 400) have been established in many farmers' fields over the years to teach about advanced soil and water management strategies and tools.

Sensor installation demonstration by Extension Educator Darrel Siekman

Sensor installation demonstration by Extension Educator Jenny Rees

In-field teaching of effective tools/technologies to farmers


05 . 17 . 2006

Datalogger programing and sensor installation demonstration

One-on-one education/teaching/demonstration is the key for successful implementation and adoption of newer technologies by farmers for water and energy conservation.


05.17.2006


05.17.2006

One-on-one interaction provides unique opportunities for more effectively educating farmers and answer their questions about real-world issues in the field. This also results in developing strong relationships and trust and confidence between us and farmers and helps to adopt our suggestions into their farming practices.

# NAWMN WEB SITE

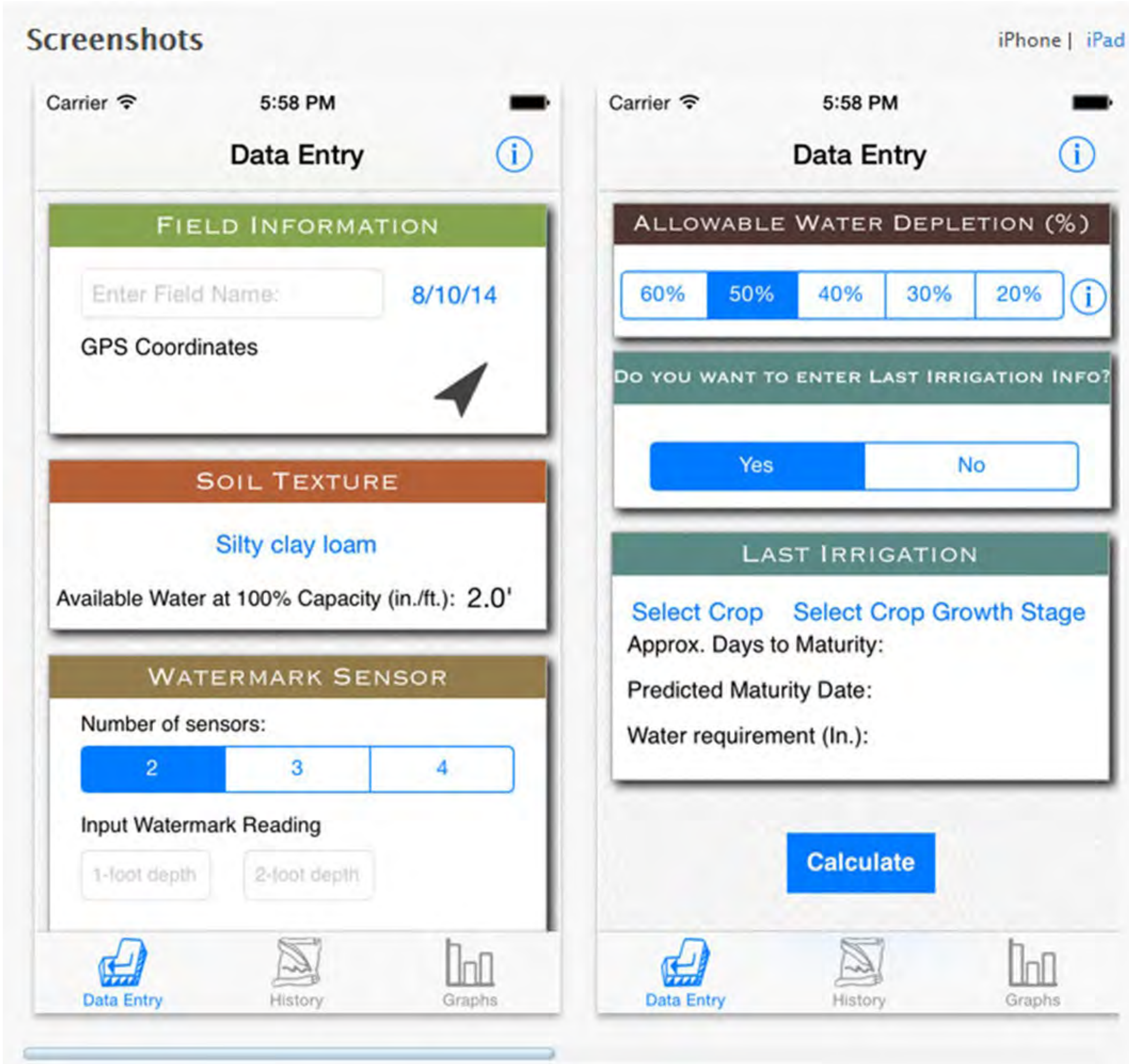
All the information and data from the Network are shared on the NAWMN website for farmers and other to use in their farming management decisions who may not be collaborator in the Network.

https://water.unl.edu/category/nawmn

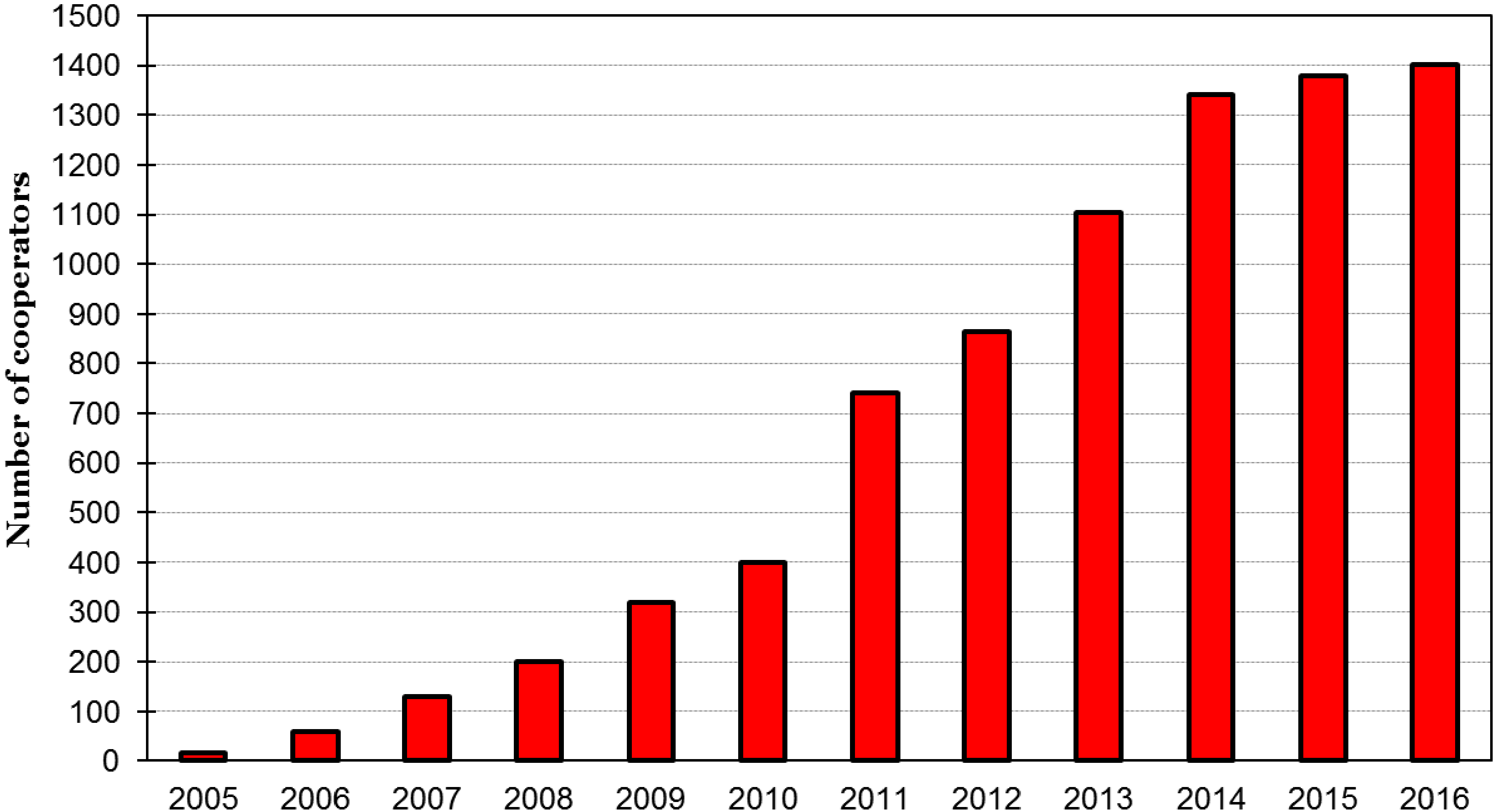
# NAWMN SMART PHONE APP on the web

https://itunes.apple.com/us/app/crop-water/id557926049?mt=8

The app estimates the water used and water still available for various soils types. User can also see historic sensor readings, graph the data, and pin his/her GPS locations.

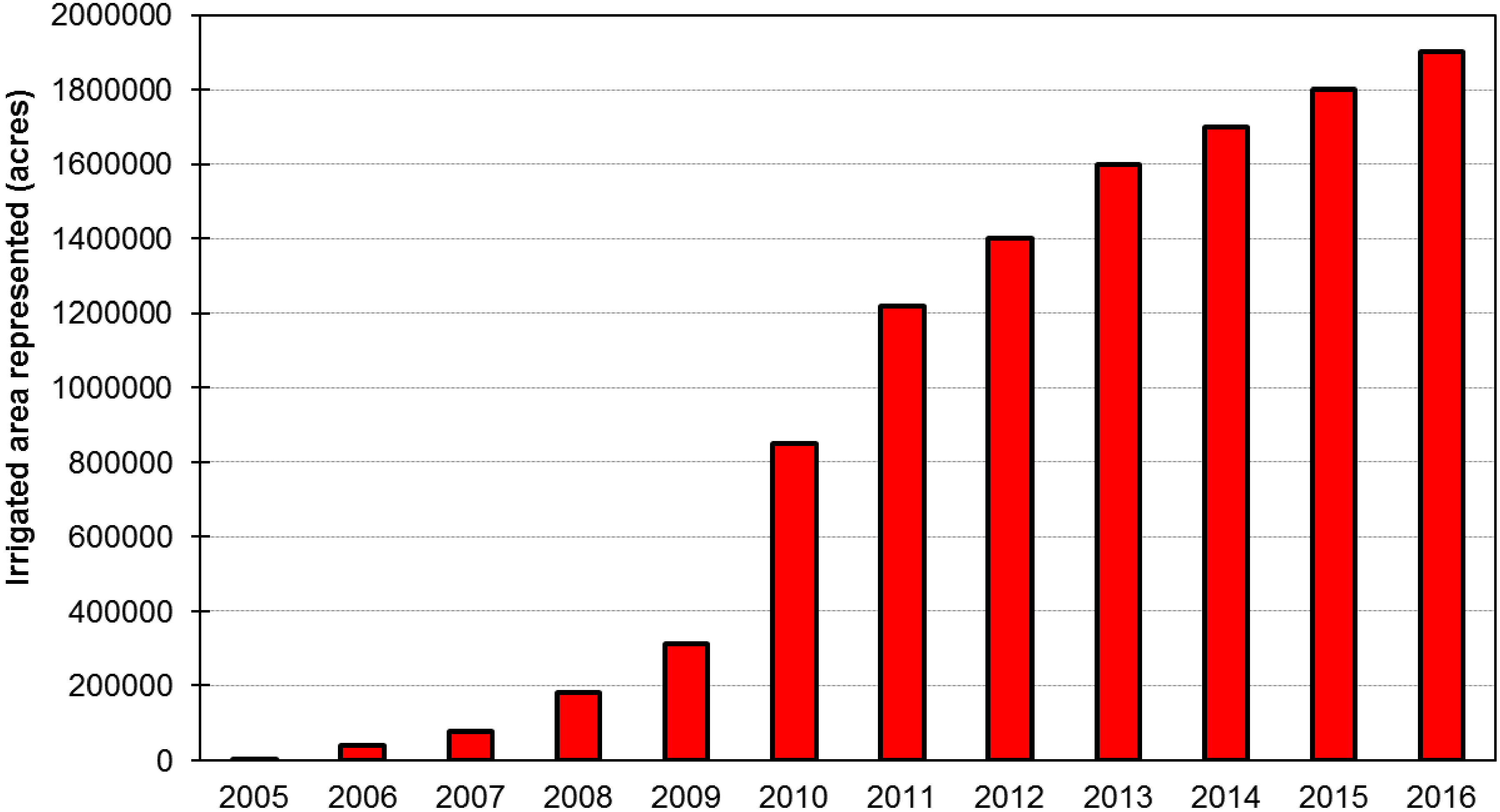

Screenshots
iPhone | iPad
Carrier
5:58 PM
Data Entry
Field Information
Enter Field Name:
8/10/14
GPS Coordinates
Soil Texture
Silty clay loam
Available Water at 100% Capacity (in./ft.): 2.0'
Watermark Sensor
Number of sensors:
2
3
4
Input Watermark Reading
1-foot depth
2-foot depth
Data Entry
History
Graphs
Carrier
5:58 PM
Data Entry
Allowable Water Depletion (%)
60%
50%
40%
30%
20%
Do you want to enter Last Irrigation Info?
Yes
No
Last Irrigation
Select Crop
Select Crop Growth Stage
Approx. Days to Maturity:
Predicted Maturity Date:
Water requirement (In.):
Calculate
Data Entry
History
Graphs

# Impact: Number of farmer cooperators in the NAWMN

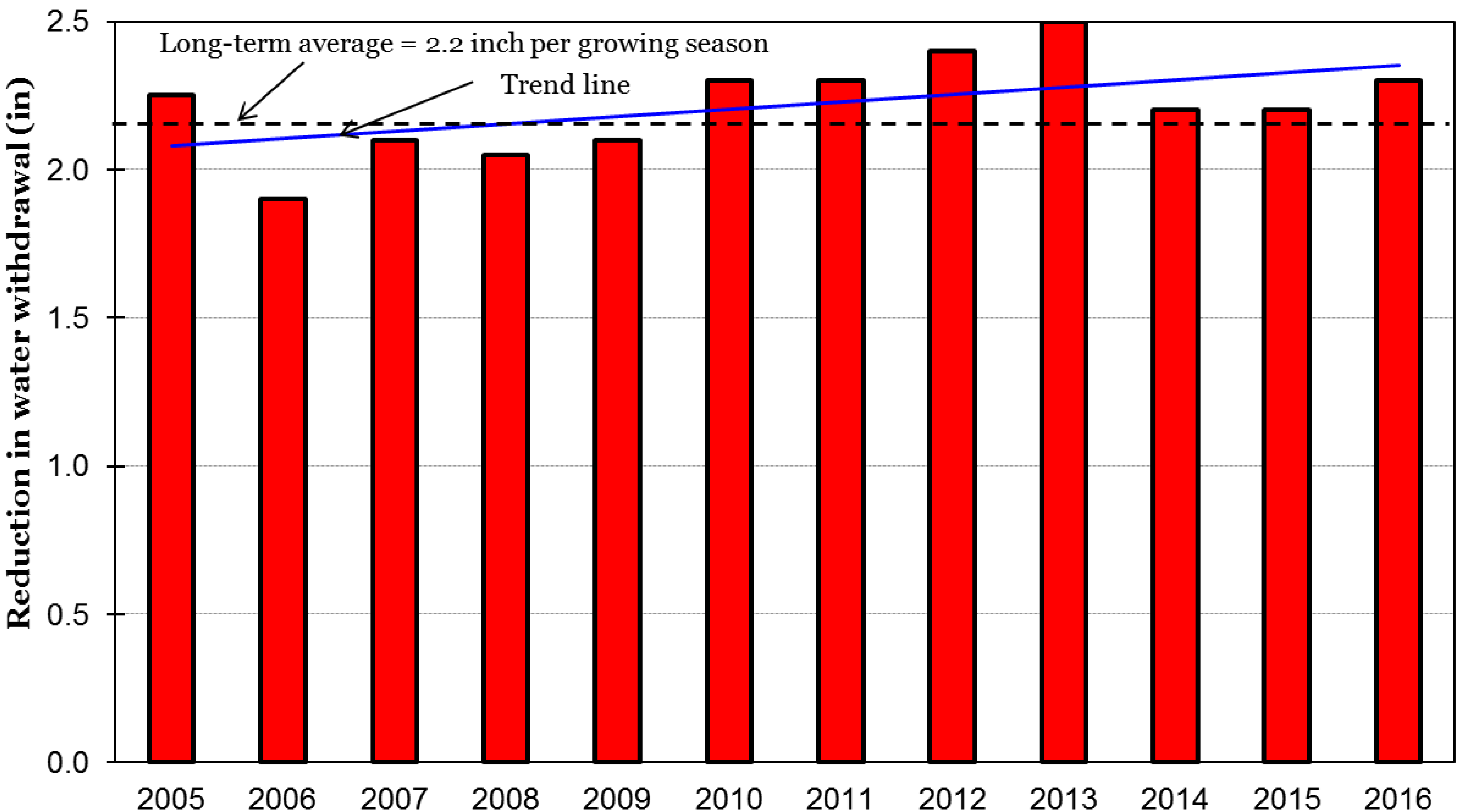


# Location of each cooperator’s field

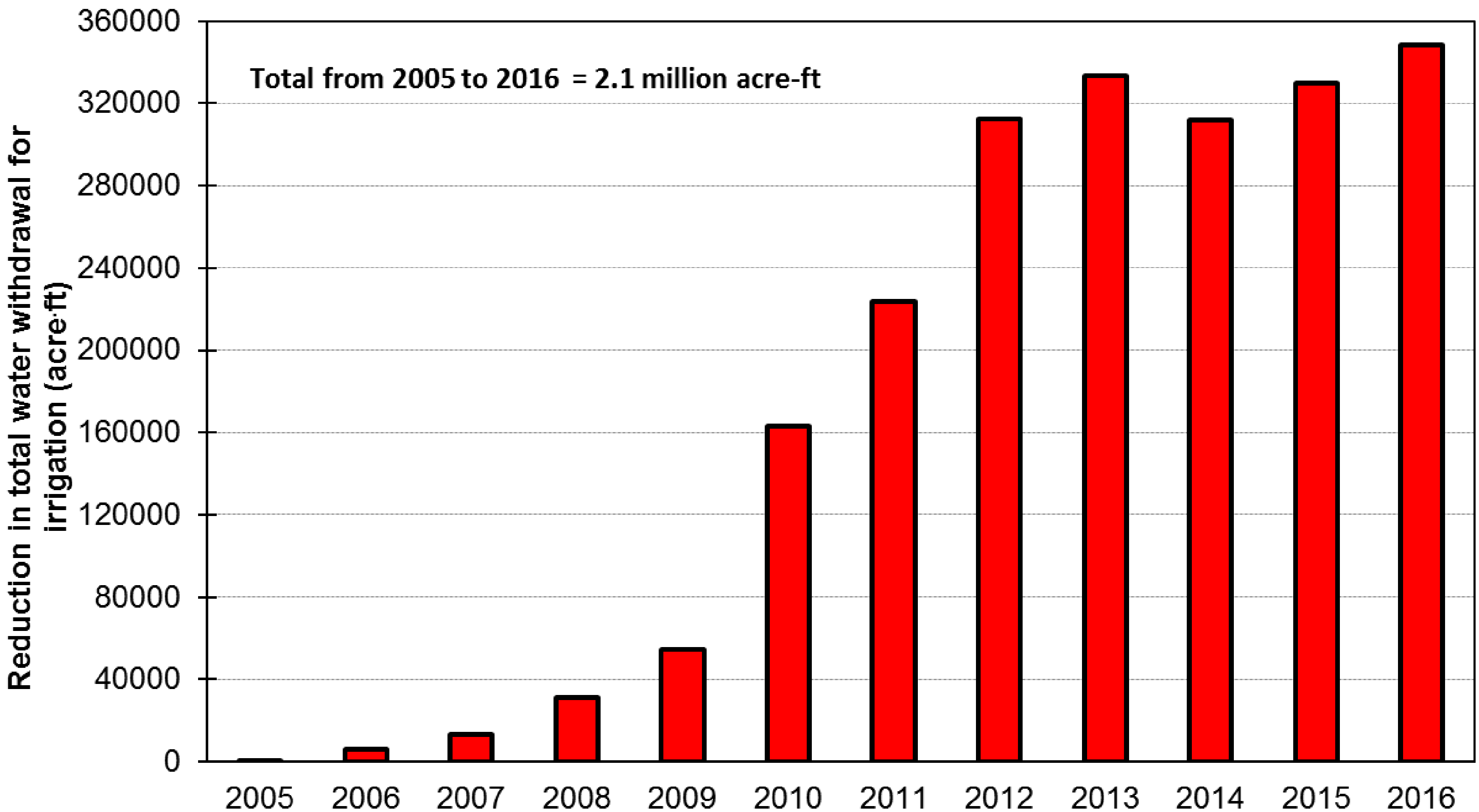
# Impact: Irrigated land area represented by NAWMDN collaborators



# Impact: Average reduction in irrigation water withdrawal per season

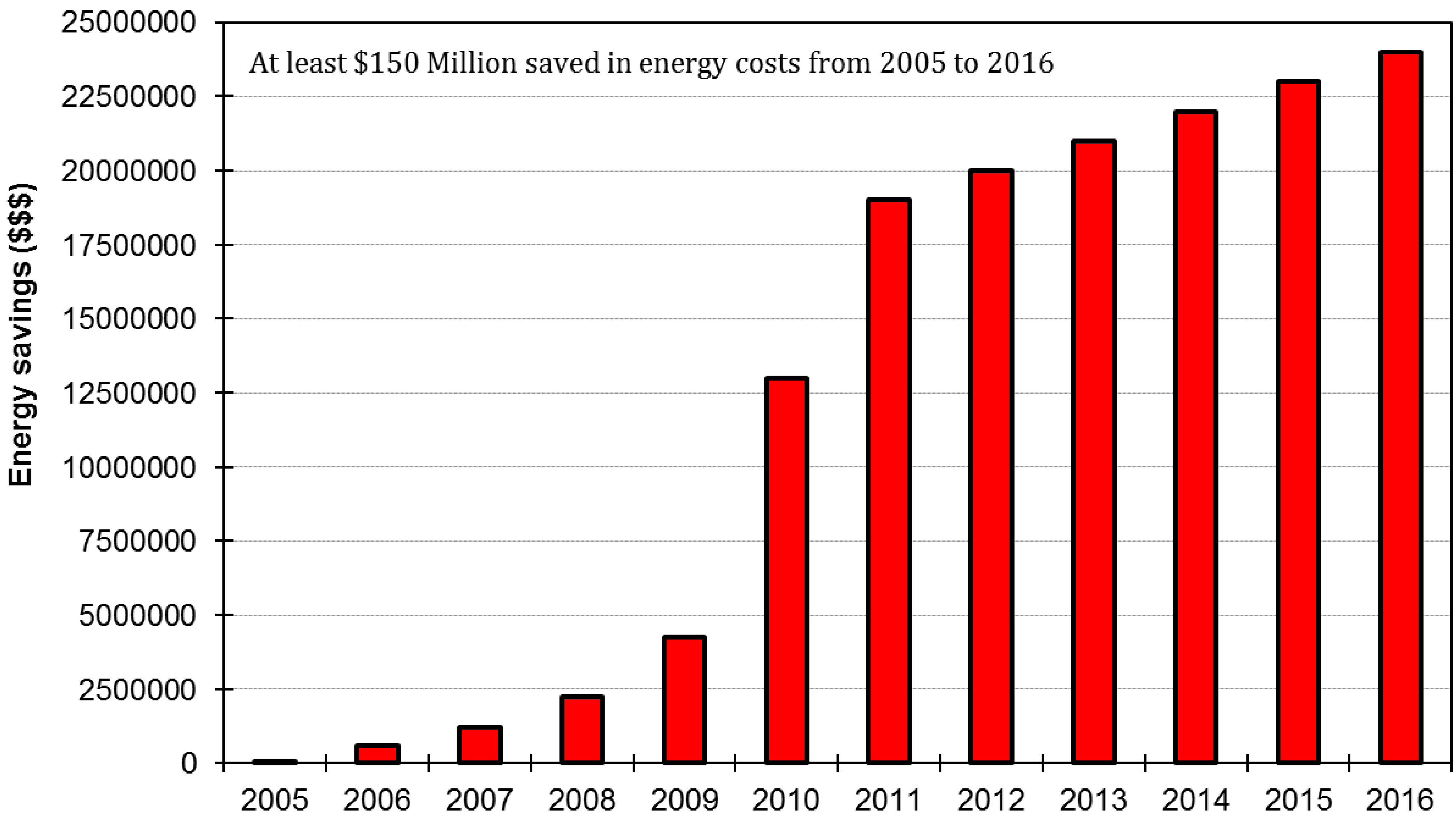


# Impact: Total reduction in water withdrawal for irrigation per season




Lake McConaughy capacity = 1,740,000 ac-ft (almost 20% of LM capacity in 2012 alone)

# Impact: $ saving in energy use/cost



# Impact:

- NAWMN became the largest agricultural water management network in the US and is being replicated as a model in other states.
- It's quantitative impacts are well-documented with significant amount of water and energy conservation with substantial positive impacts to the state and environment.
- NAWMN changed the behavior of our citizens and established and helped to maintain a culture of technology implementation in agricultural water management.

# Impact:

- The project began in 2005 with 15 producers and 1,482 acres. The number of active collaborators has increased to over 1,400 in 17/23 of the Nebraska Natural Resource Districts and 70 of 93 counties in Nebraska.

- Since the beginning of the Network, over 15,000 farmers, crop consultants, and agricultural industry personnel have been reached with over 600 extension/education/outreach programs.

- Nebraska is now ranked #2 in technology use in agricultural water management.

- NAWMN helped to enhance the visibility of UNL in the national and international platforms.

# Impact

- "*USDA-NIFA NATIONAL INNOVATIVE PROGRAMS AND PARTNERSHIP AWARD*" (first in *UNL's history*) for NAWMN's groundbreaking water management work and contributions in advancing agricultural science. Presented by the USDA Undersecretary Dr. Catherine Woteki and the USDA-NIFA Director Dr. Sonny Ramaswamy. October 23, 2014. Washington, DC.

Effective and relevant education programs are critical for information, data and knowledge dissemination to have positive impact in large scales!

In-field teaching using NAWMN platform to educate and enhance scientific literacy of farmers, crop consultants, state and federal agency personnel, and other professionals in various topics related to water, crop production, crop physiology, climate, evapotranspiration, soil-water-plant-atmosphere continuum.


Water for Food
NEBRASKA WATER CENTER


PERFORMANCE OF SOIL MOISTURE
SENSORS IN COARSE AND
FINE-TEXTURED SOILS


EXTENSION


66

# Critical importance of partnership and collaboration

- Quantifying and studying the changes in climate variables can help to develop sustainable agricultural and water resources assessment, allocation, management and forecasting strategies and tools as well as more realistic and effective policy- and decision-making.

- If these can be accomplished through a strong partnership between scientists/researchers/engineers, government agencies, policymakers, non-profit and for-profit institutions, and other institutions, this can enable effective programs towards adapting agricultural practices to a changing climate to sustain or even enhance national agricultural productivity, economy and well-being of citizens.

- Policy- and decision-making must be based on science and research. And, politics must be separated from science and research to help citizens to enhance their agricultural productivity. The good of citizens, environment, next generation must be priority, not our own personal opinion.

# United States Senate

# United States House of Representatives

# Thank you!

***"Science is the father of knowledge, but opinion breeds ignorance"***

***Hippocrates, 460BC–370 C.***

**Suat Irmak, Ph.D.**
**Harold W. Eberhard Distinguished Professor**
**University of Nebraska - Lincoln**
**239 L.W. Chase Hall**
**P.O. Box 830726 Lincoln, NE 68583-0726**
**Ph: (402) 472-4865; E-mail: sirmak2@unl.edu**