AGRICULTURAL TECHNOLOGIES TO MITIGATE NEGATIVE IMPACTS OF CLIMATE CHANGE AND ENHANCE PRODUCTION EFFICIENCY

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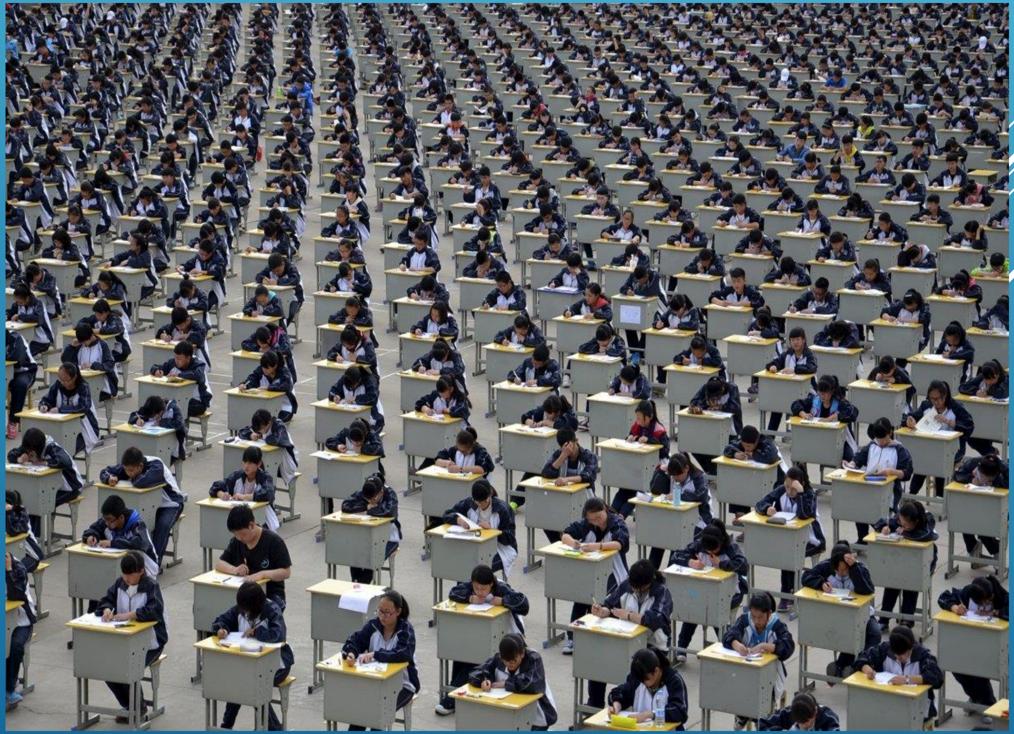
World’s population will grow from around 7.6 billion people today to 8.3 billion people in 2030 and over 9.5+ billion 2050. Turkiye’s population in 2018 was 80.8 million.



The world is facing an impending water shortage that will complicate national and global efforts to alleviate and prevent food shortages in many regions.

The USA has been impacted by decreasing irrigation water availability in many regions, including Great Plains. But, no region in the world is immune to these challenges!

Many areas in the world are facing significant challenges due to temperature and solar radiation increase, which, in turn, increase vapor pressure deficit and evaporative losses.

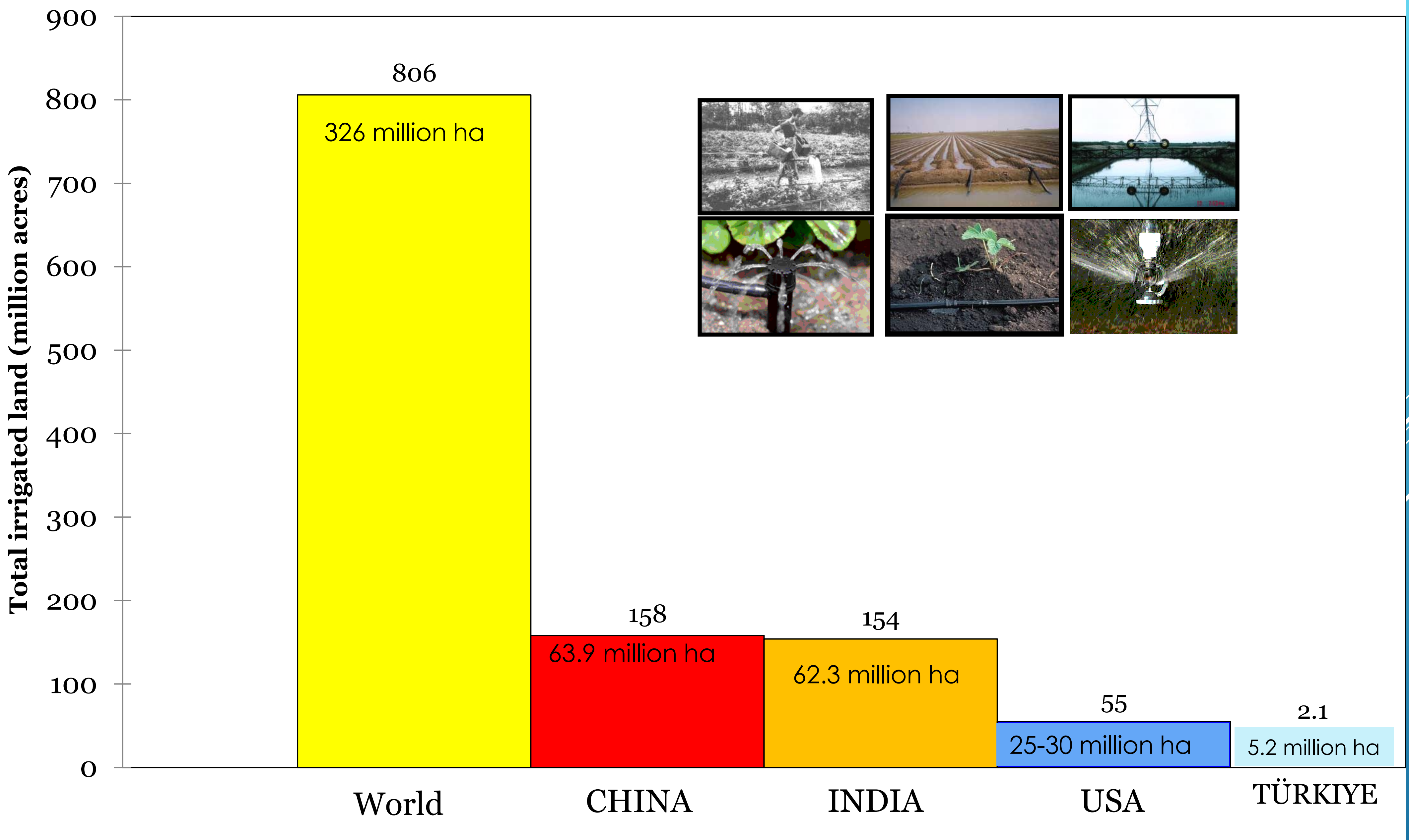
In Turkiye, T_{max} has increased by about 1.6^{o}C; T_{min} has increased by about 2^{o}C; and T_{avg} has increased by about 1.7^{o}C in the last 30 years.

On the other hand, ET_{ref} has increased by about 80 mm!

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 management practices can be developed in response to changes in climatic variables.

There are technologies to mitigate negative impacts of climate change in agriculture. Some examples include:

Irrigated land area

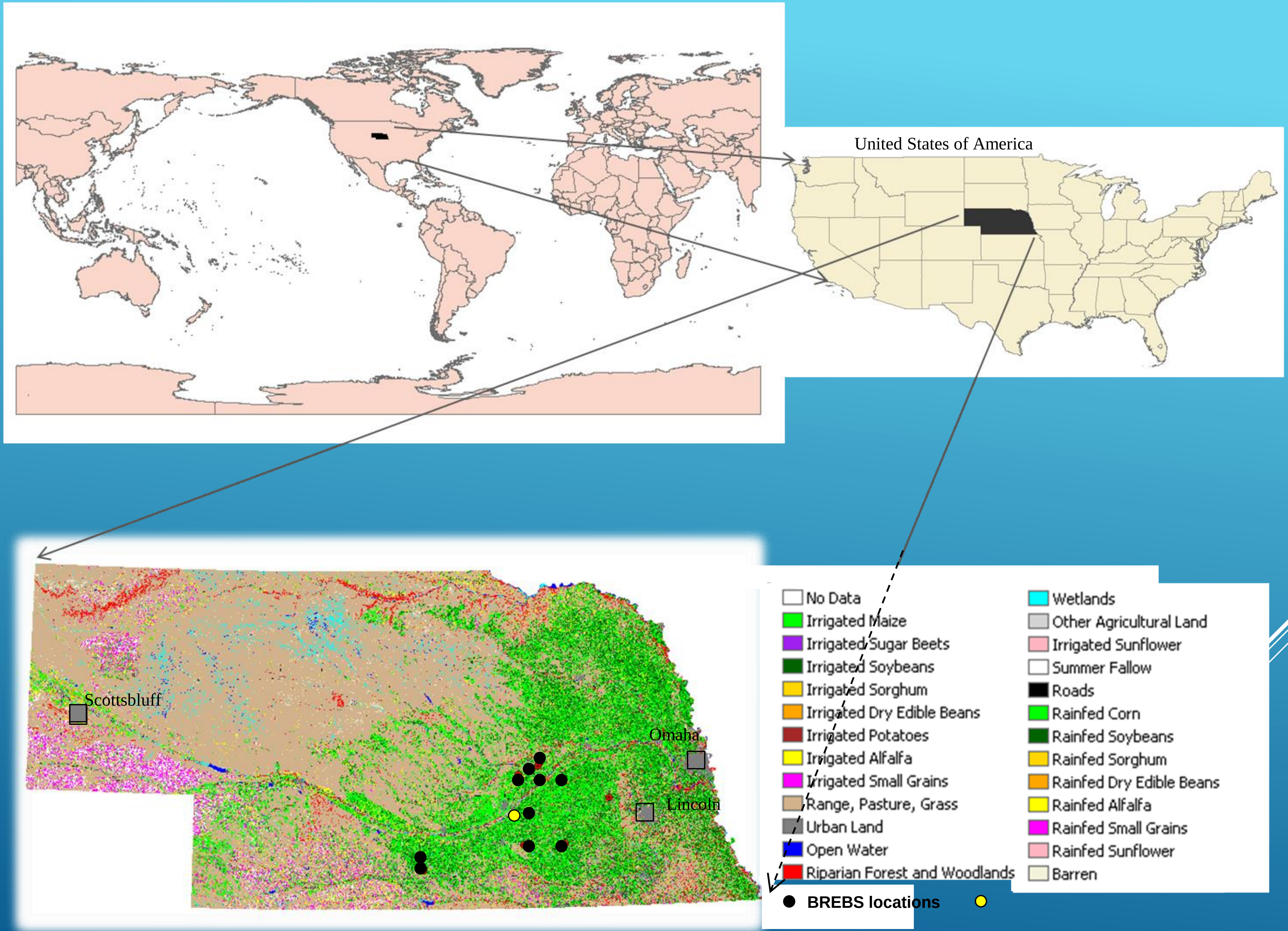


Jaredites Civilization, Sumerian Origin, 8,000 B.C.

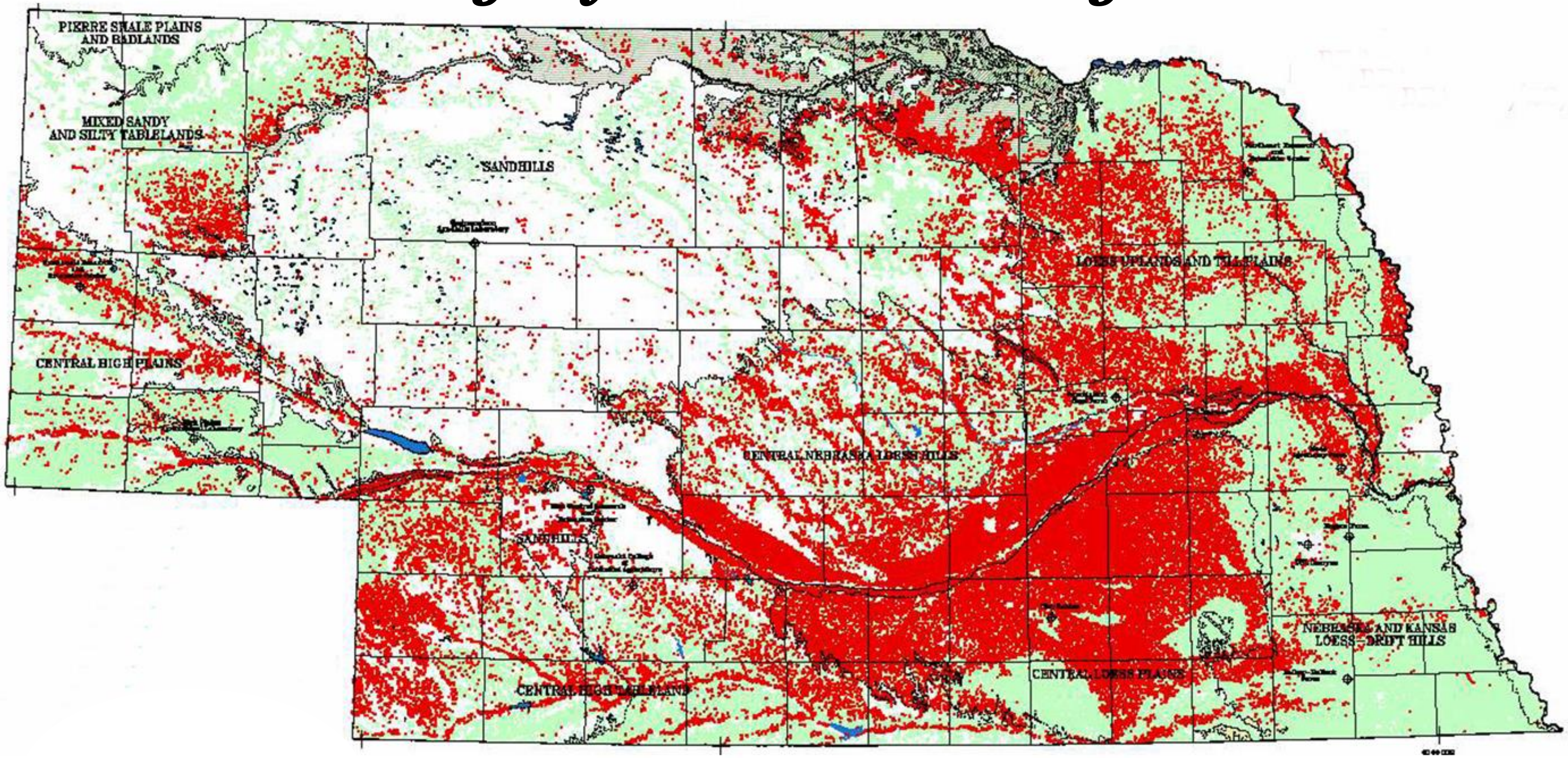
Ancient Mesopotamia/Sumerian-built irrigation canal (8,000 B.C.)

Roman aqueduct, Aspendus, Turkiye

Aqueduct conveyance (junction) system (Iasos, Turkiye)


United States of America
Scottsbluff
Omaha
Lincoln
No Data
Irrigated Maize
Irrigated Sugar Beets
Irrigated Soybeans
Irrigated Sorghum
Irrigated Dry Edible Beans
Irrigated Potatoes
Irrigated Alfalfa
Irrigated Small Grains
Range, Pasture, Grass
Urban Land
Open Water
Riparian Forest and Woodlands
Wetlands
Other Agricultural Land
Irrigated Sunflower
Summer Fallow
Roads
Rainfed Corn
Rainfed Soybeans
Rainfed Sorghum
Rainfed Dry Edible Beans
Rainfed Alfalfa
Rainfed Small Grains
Rainfed Sunflower
Barren
BREBS locations

More than 115,000 active irrigation wells create challenges for water management



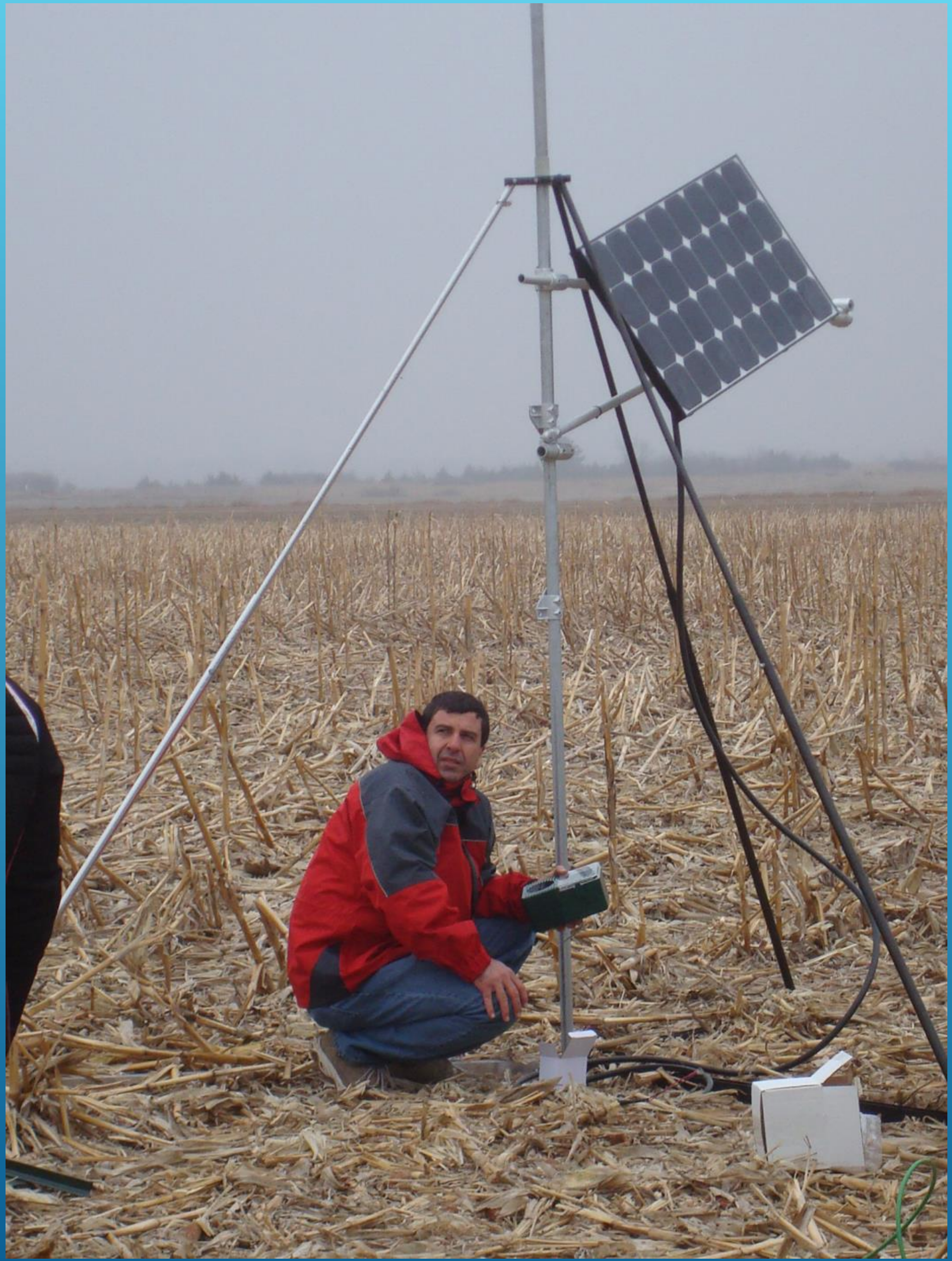
Irrigation wells

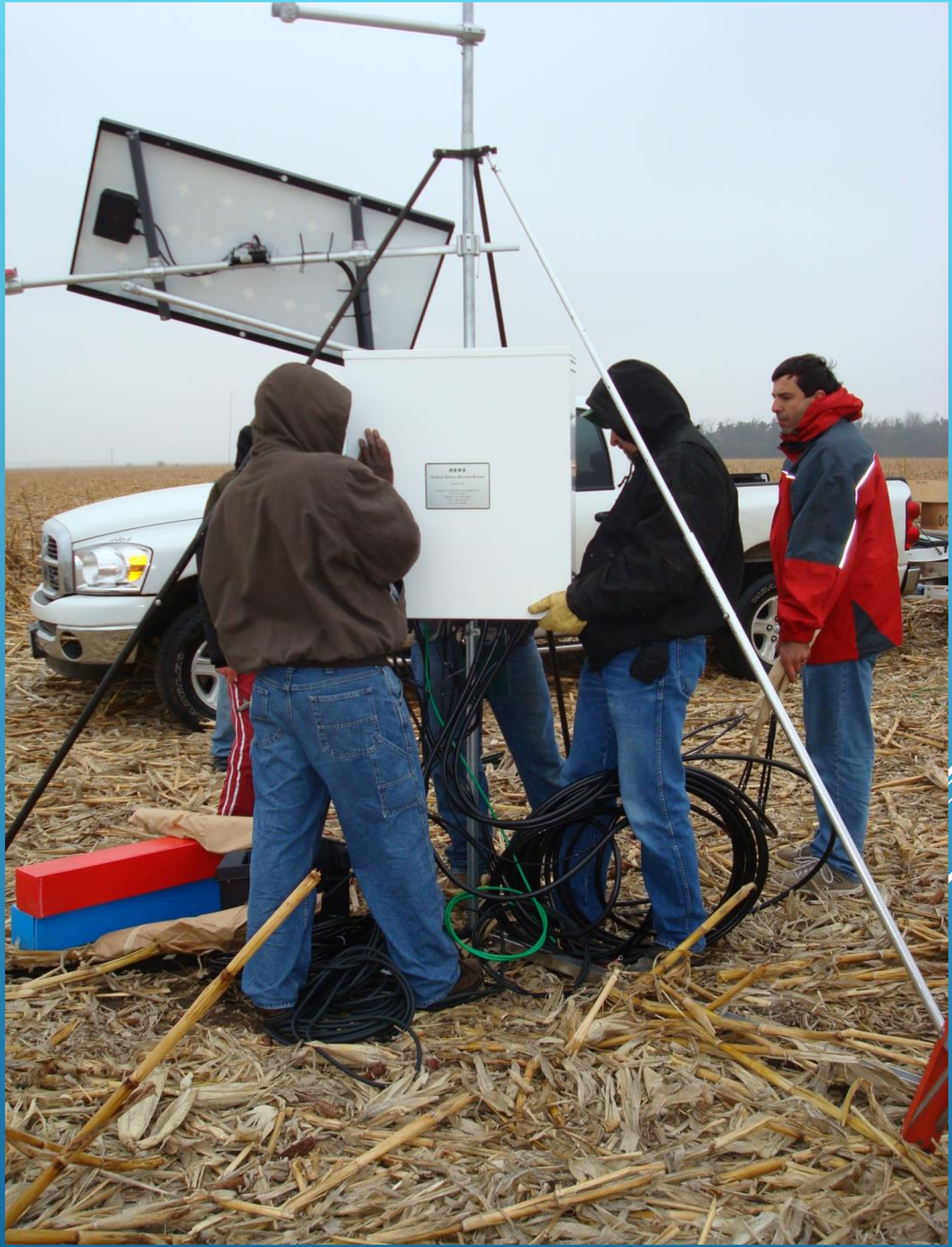
University of Nebraska Lincoln

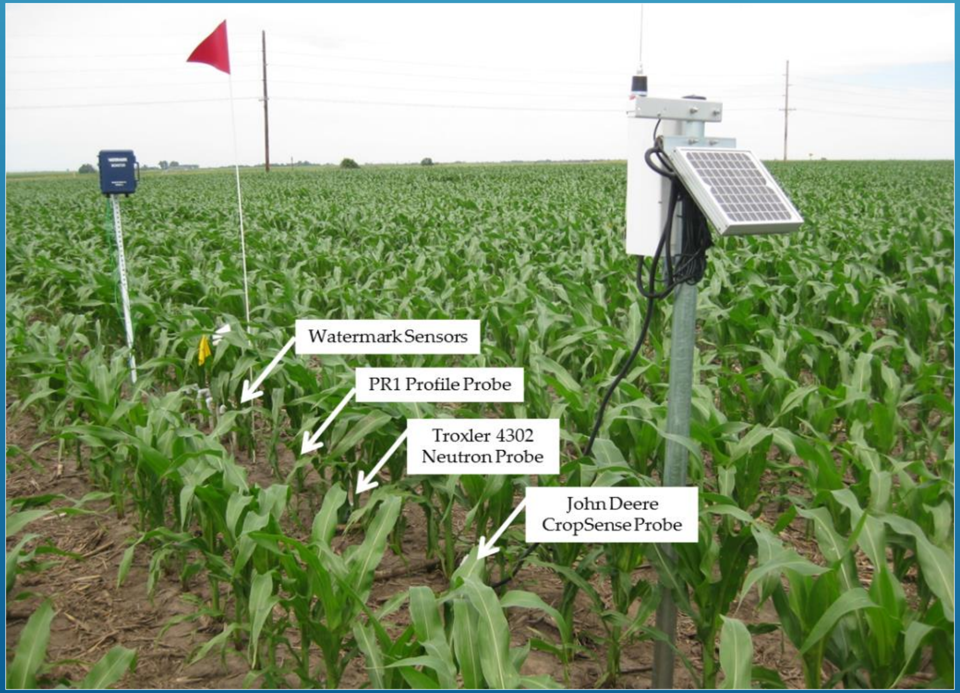
Soil management practices

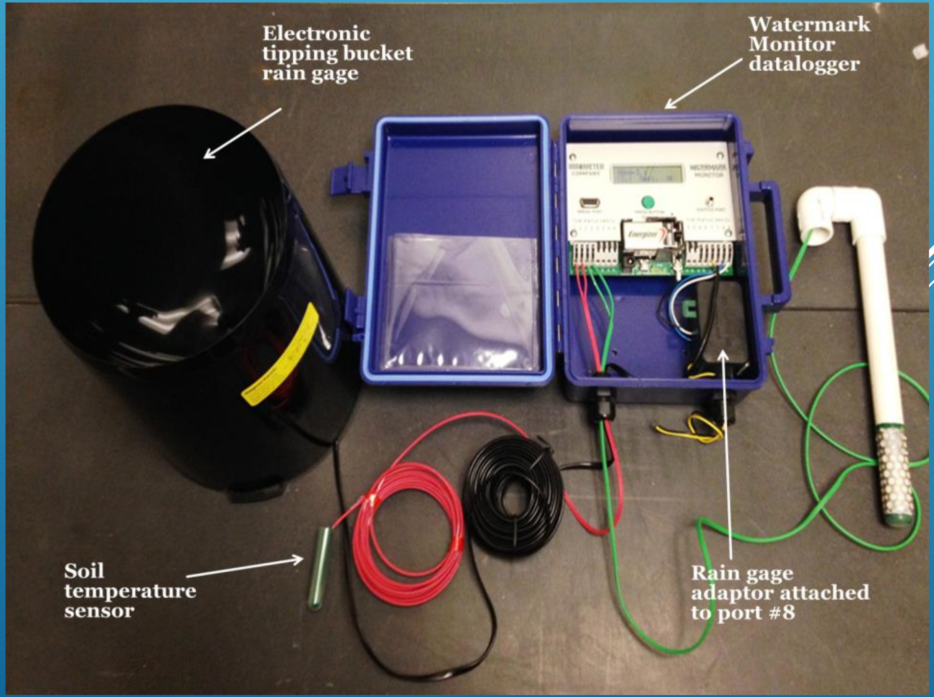

446A
DO NOT PUSH


16167

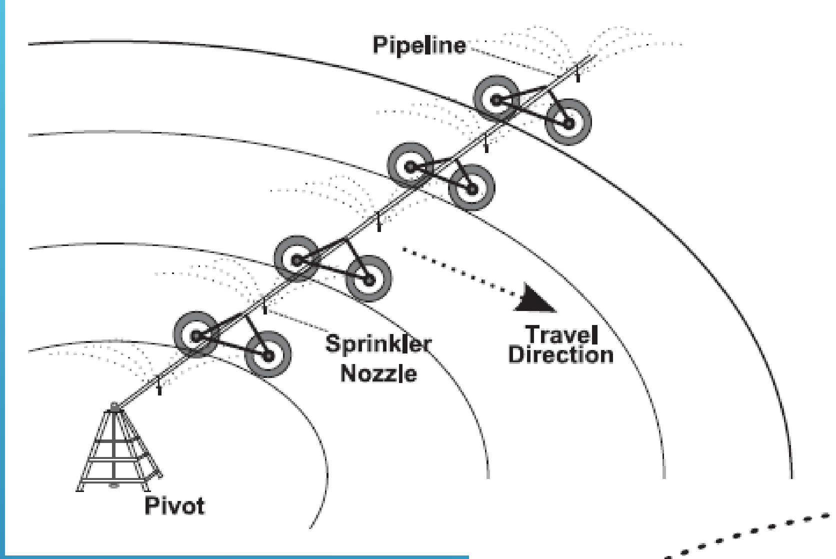


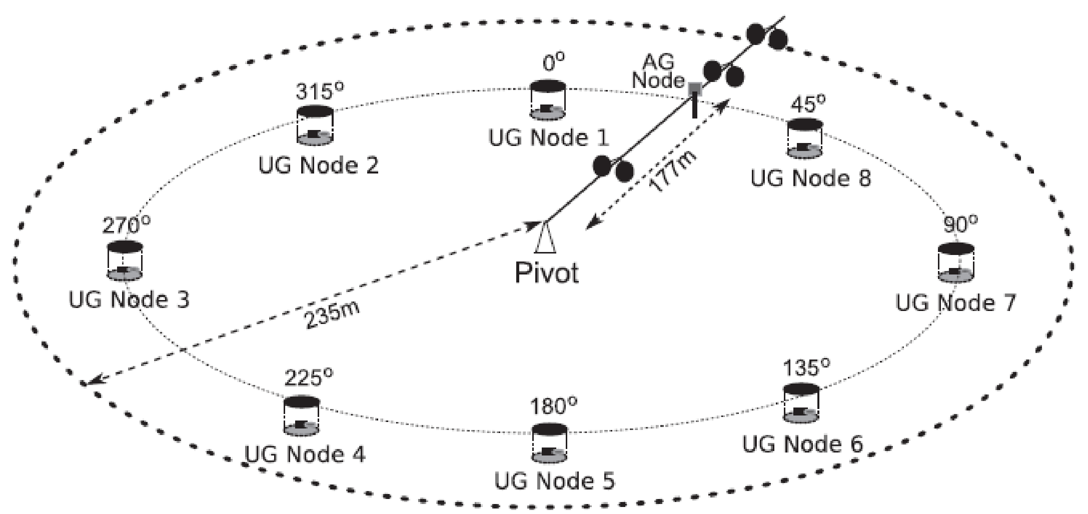



Watermark Sensors
PR1 Profile Probe
Troxler 4302
Neutron Probe
John Deere
CropSense Probe


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

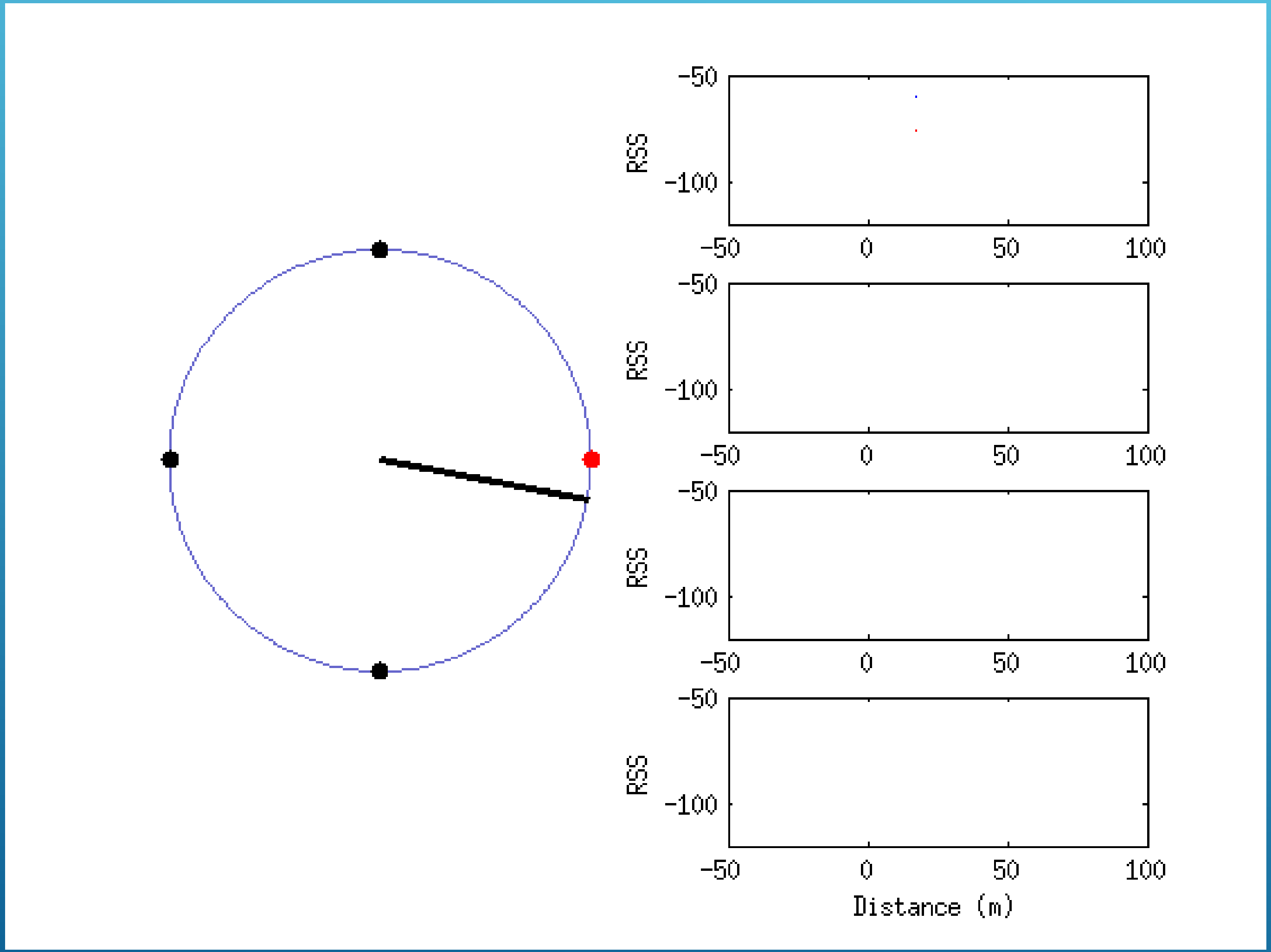
Underground & Wireless Sensor Network





An example of a precision agriculture cyber-physical system, WUSA-CP, based on Wireless Underground Sensor Networks (WUSNs). A WUSN can employ three kinds of communication: underground-to-underground (UG2UG), underground-to-aboveground (UG2AG), and Aboveground-to-underground (AG2UG).

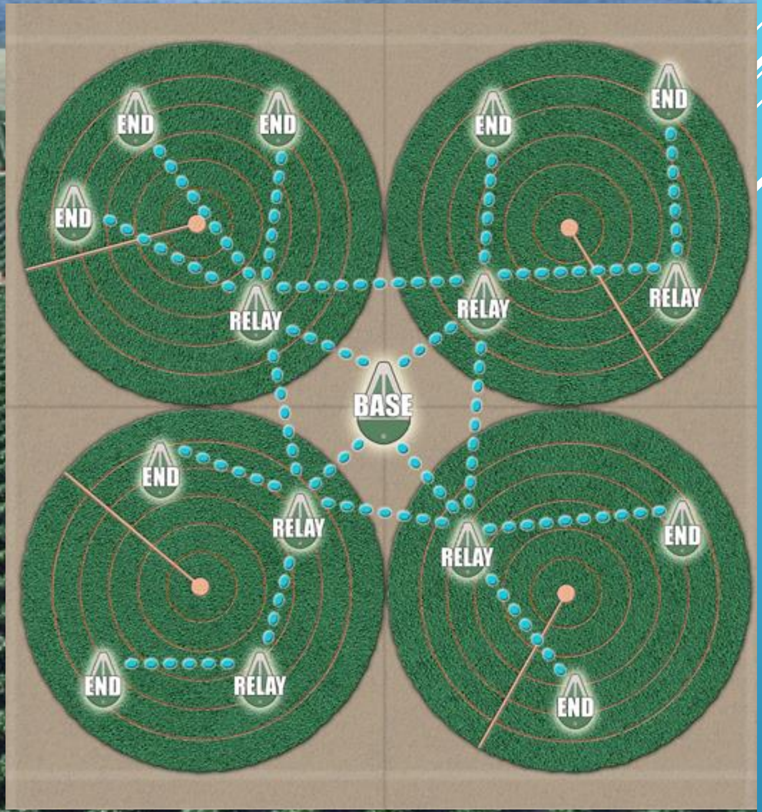
Next generation real-time autonomous irrigation management—Irmak-SCAL NE Center Pivot

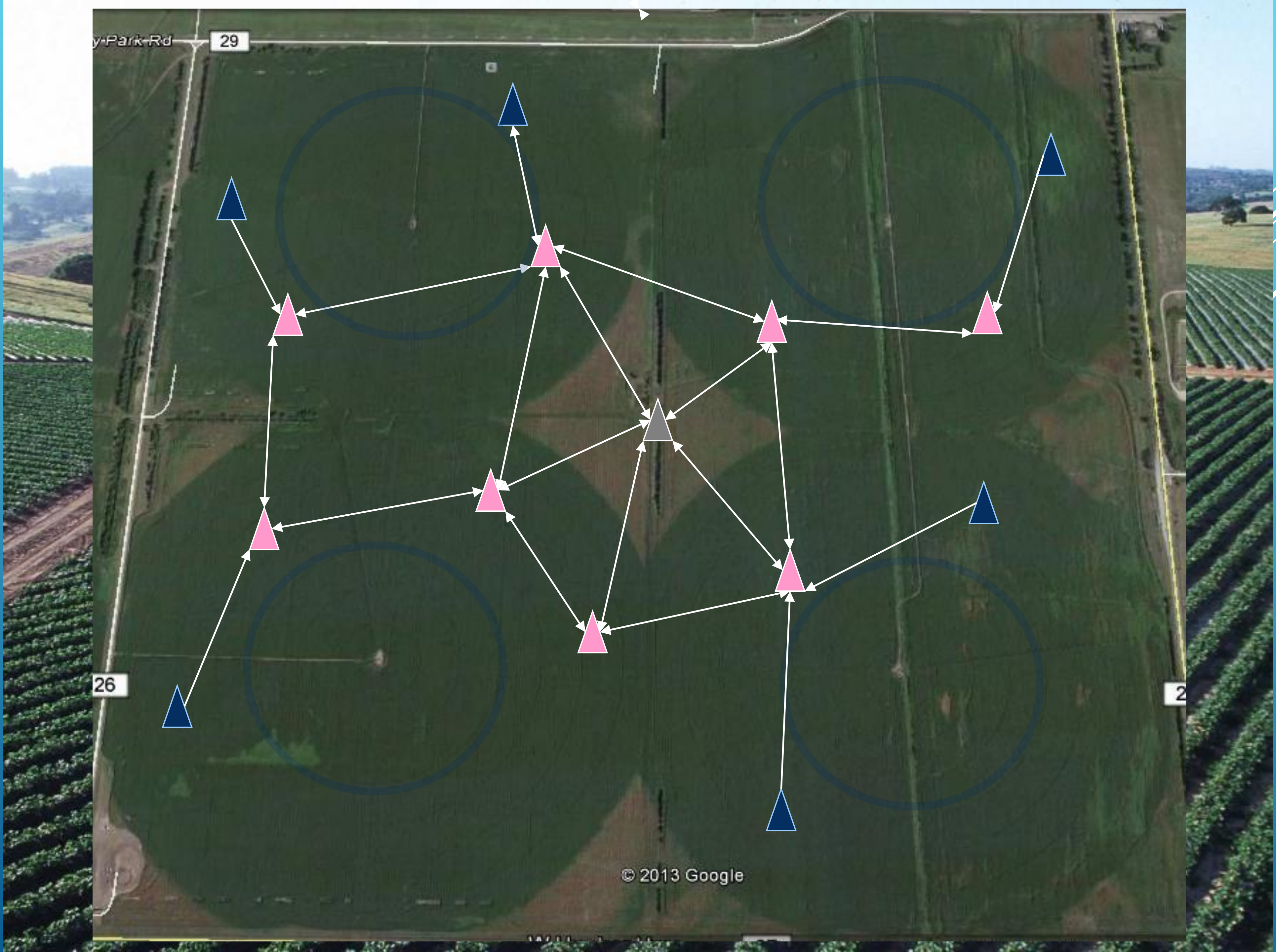


UG2AG
AG2UG

- Four UG nodes buried
- When pivot moves
    - AG node polls soil moisture data
- Communication starts when
    - Pivot > 160 ft away
- RSS increases
    - moves towards UG nodes
- Communication continues after
    - pivot passes the UG node 82 ft
- RSS decreases
    - moves away from UG nodes

MESH Radio Networks




y Park Rd
29
26
© 2013 Google

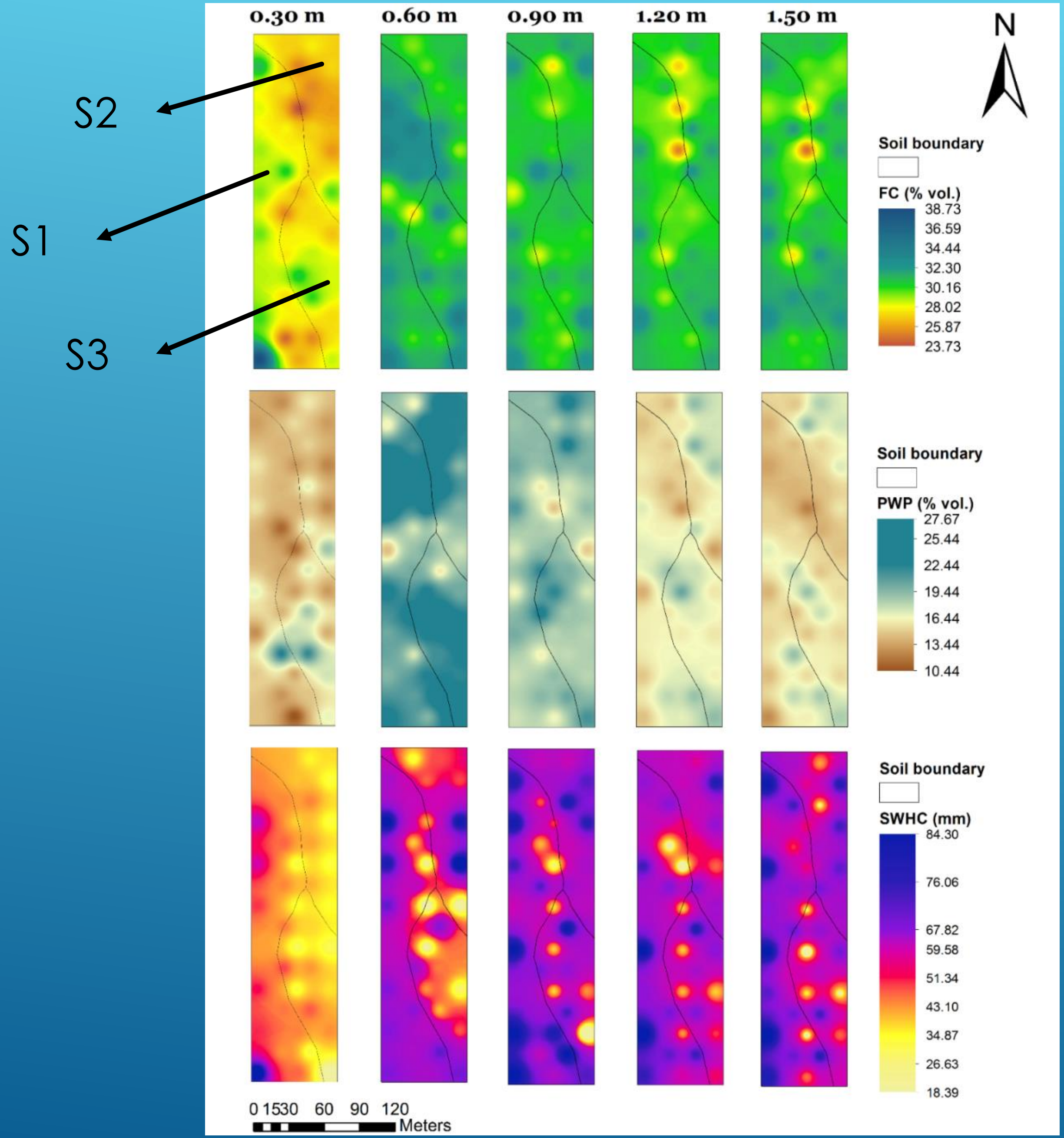
Irmak S-Spatiotemporal Soil Moisture Distribution-CP.avi

Reducing harvest losses

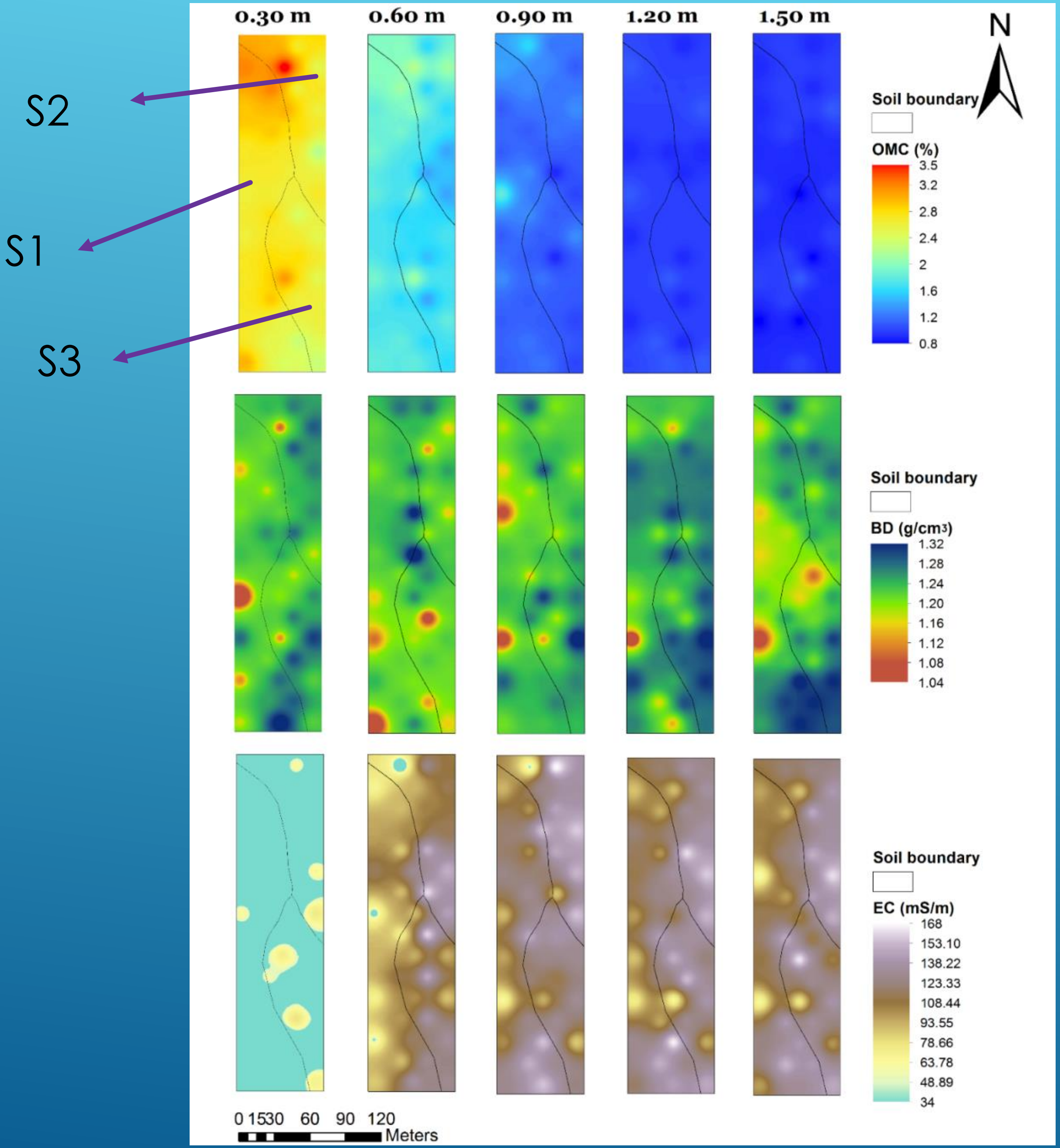
Subsurface drip irrigation

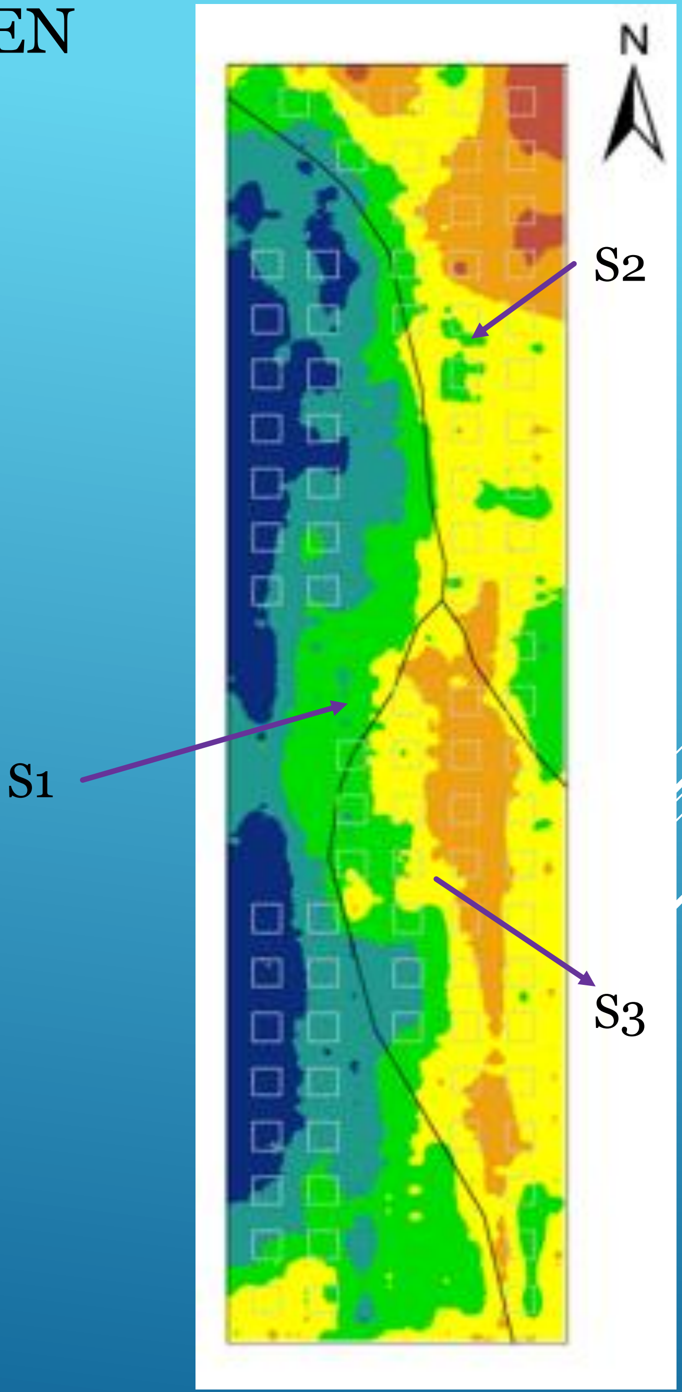
Precision Mobile Drip Irrigation

PRECISION MANAGEMENT-SOIL PROPERTIES: FC, PWP AND SWHC

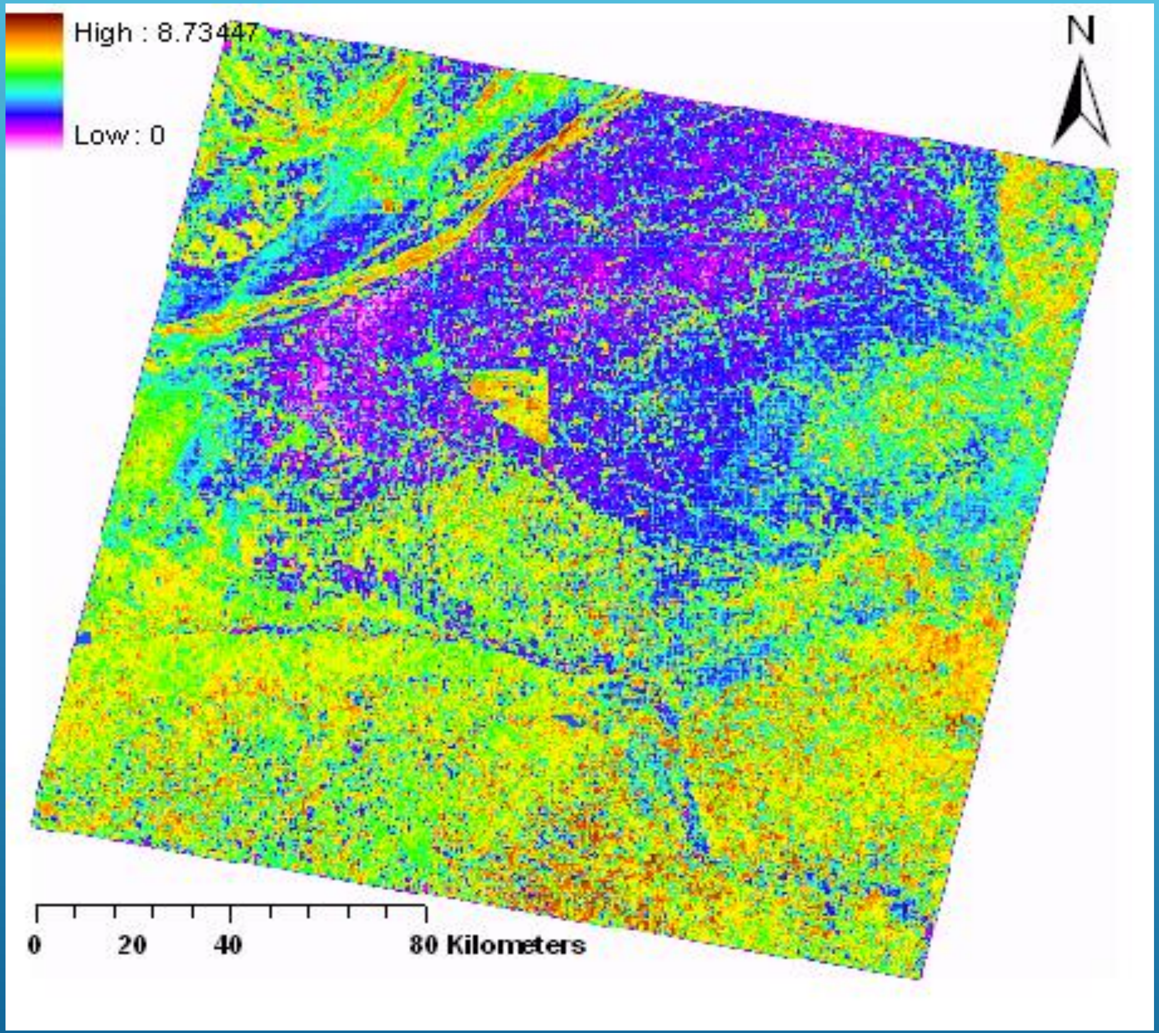


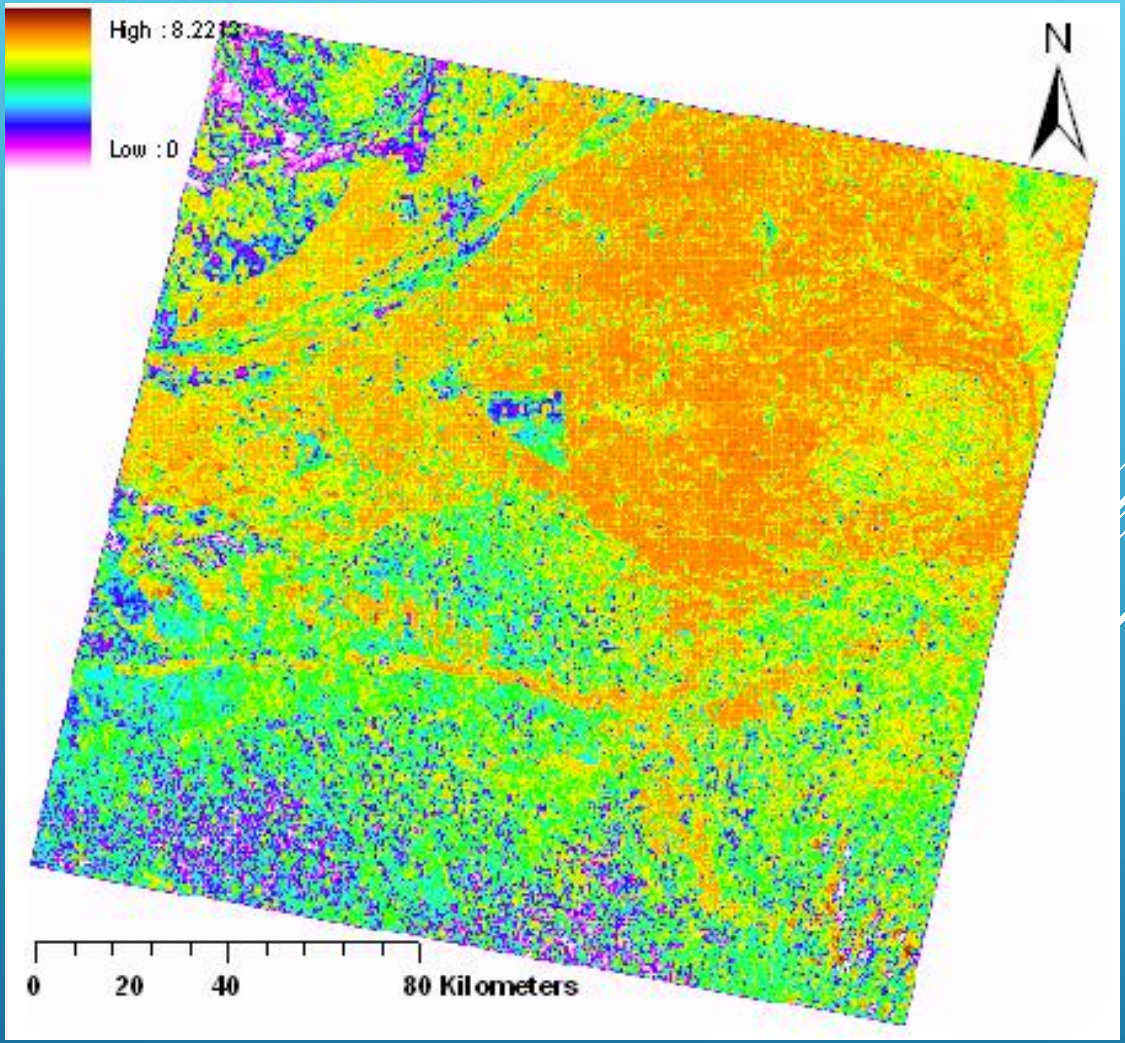
PRECISION MANAGEMENT: OMC, BD, EC AND NITROGEN

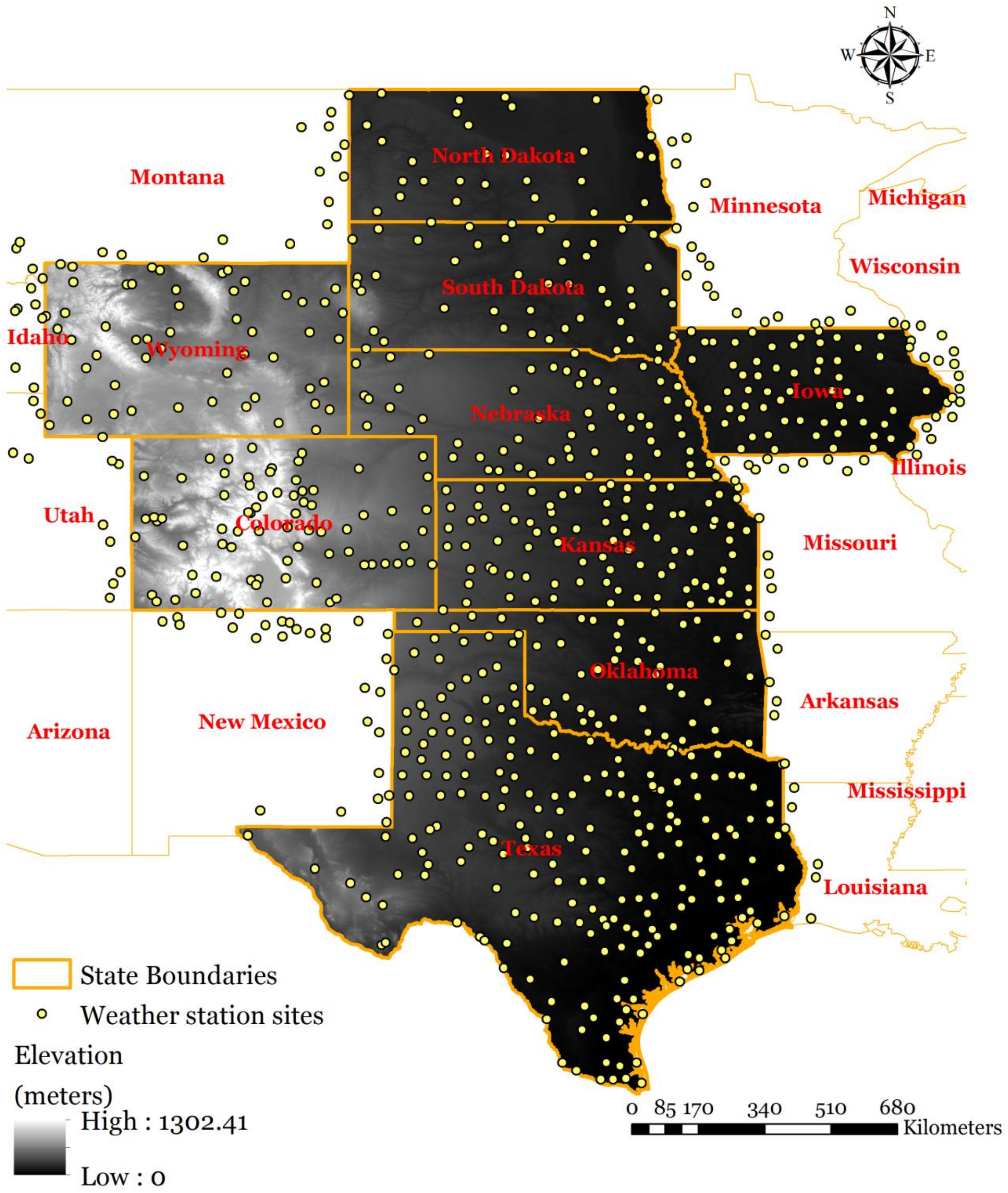


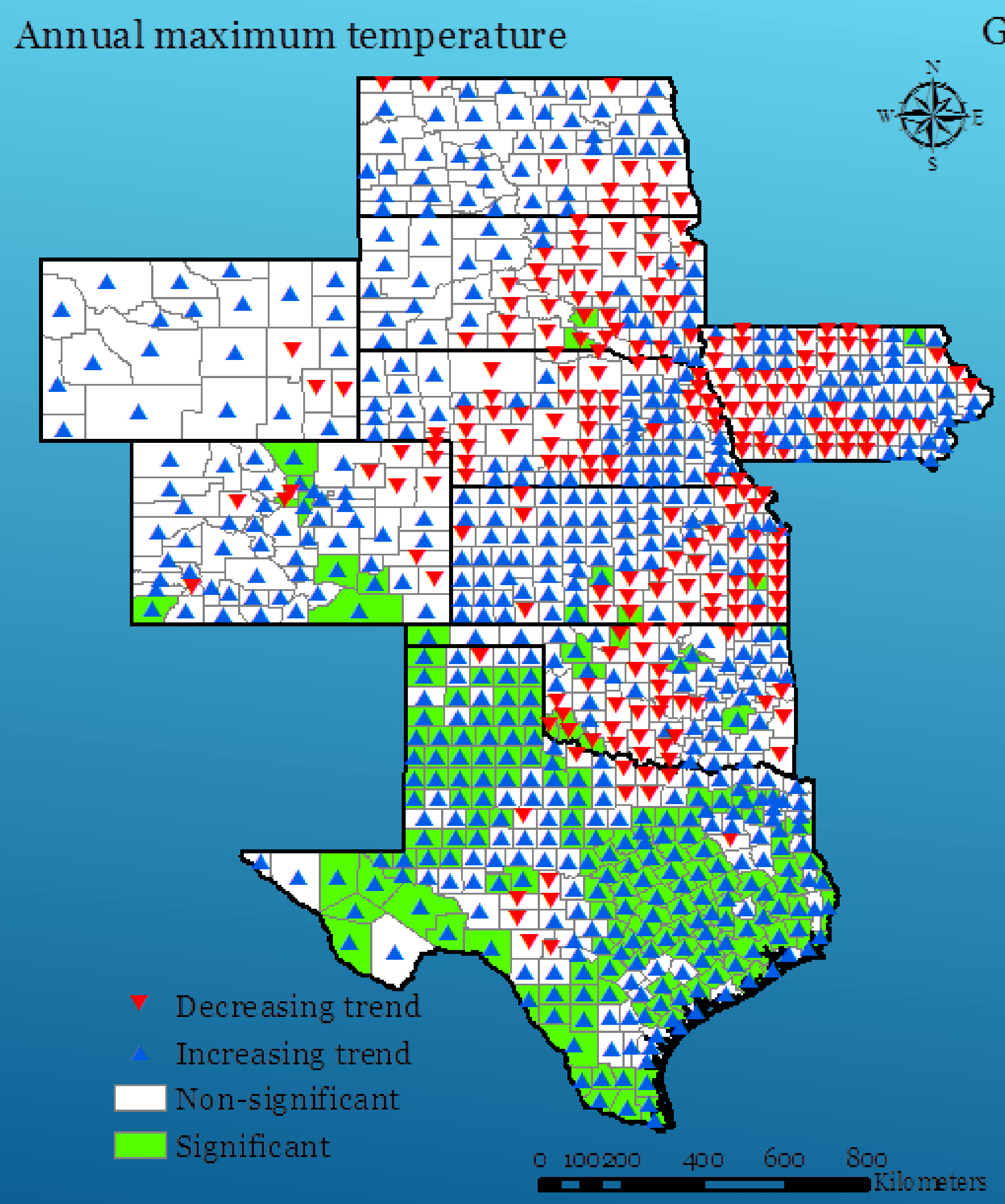


Remote Sensing/Satellite Estimation of Agricultural Practices and Processes

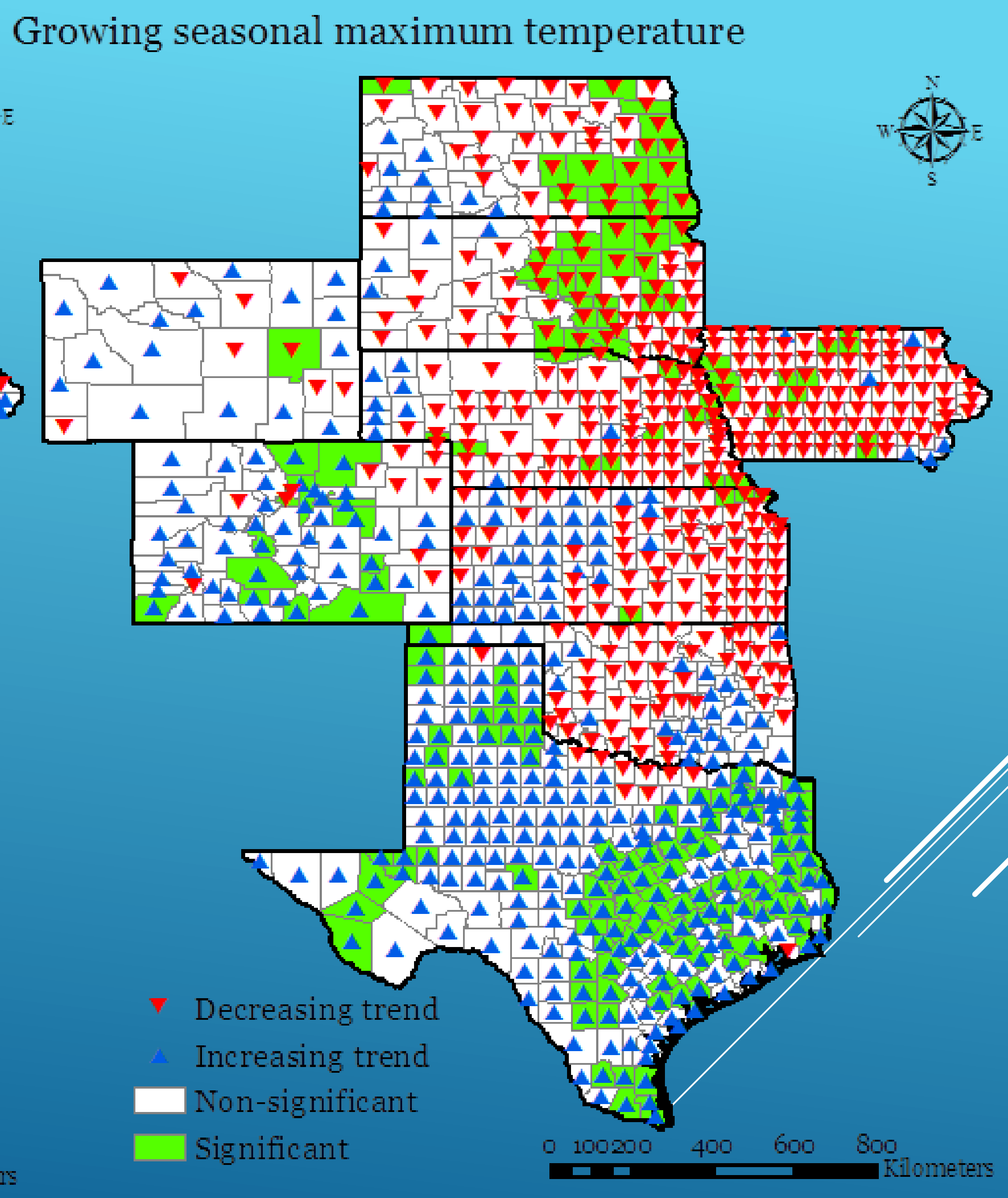





N
W
E
S
Montana
North Dakota
Minnesota
Michigan
South Dakota
Wisconsin
Idaho
Wyoming
Iowa
Nebraska
Illinois
Utah
Colorado
Kansas
Missouri
Oklahoma
Arkansas
Arizona
New Mexico
Mississippi
Texas
Louisiana
State Boundaries
Weather station sites
Elevation
(meters)
High : 1302.41
Low : 0
0 85 170 340 510 680
Kilometers

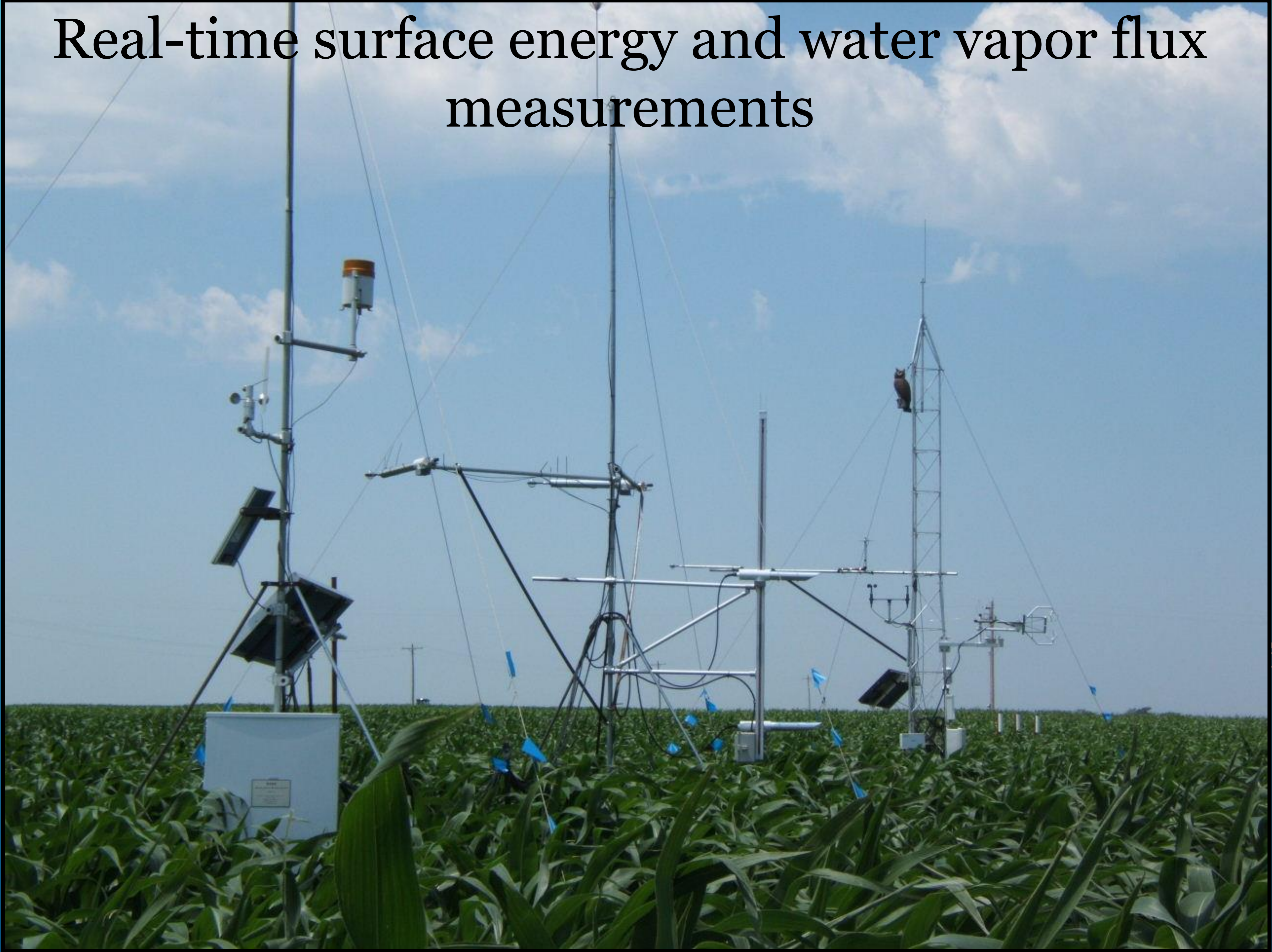


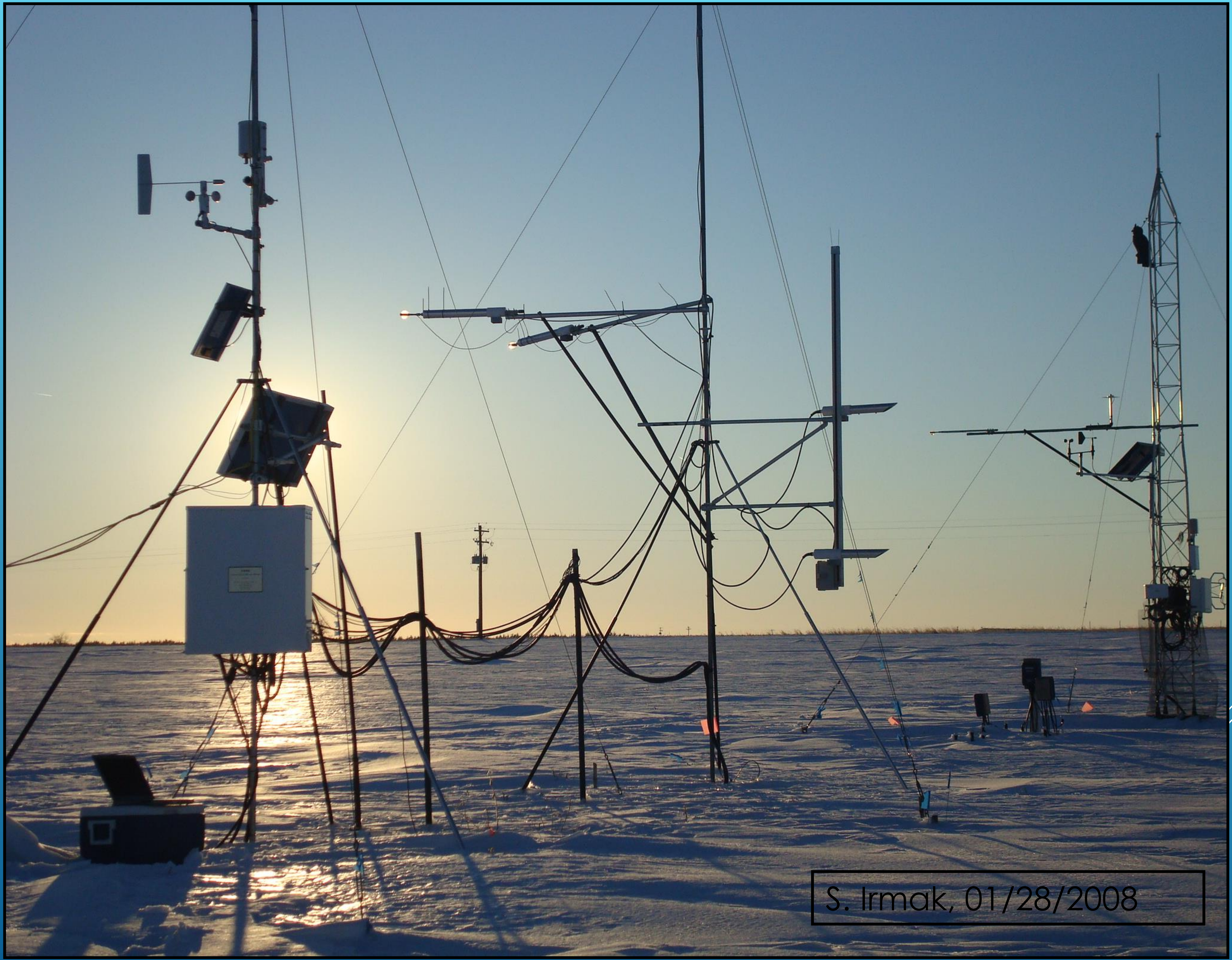
Annual maximum temperature
N
W
E
S
Decreasing trend
Increasing trend
Non-significant
Significant
0 100200 400 600 800
Kilometers

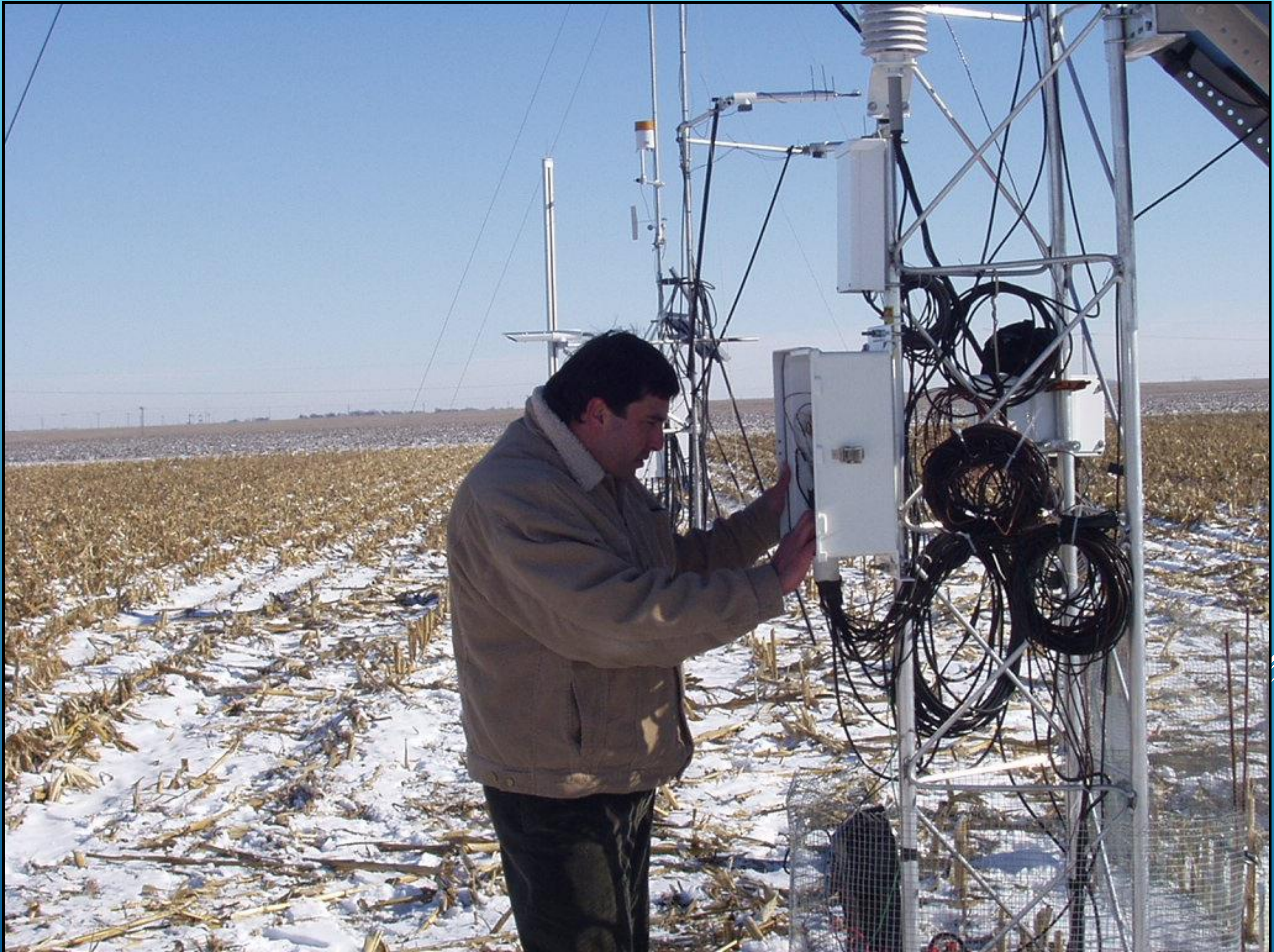


Growing seasonal maximum temperature
N
W
E
S
Decreasing trend
Increasing trend
Non-significant
Significant
0 100200 400 600 800
Kilometers

Real-time surface energy and water vapor flux measurements




S. Irmak, 01/28/2008



Annual PET
55.1 in
Annual PET
55.1 in

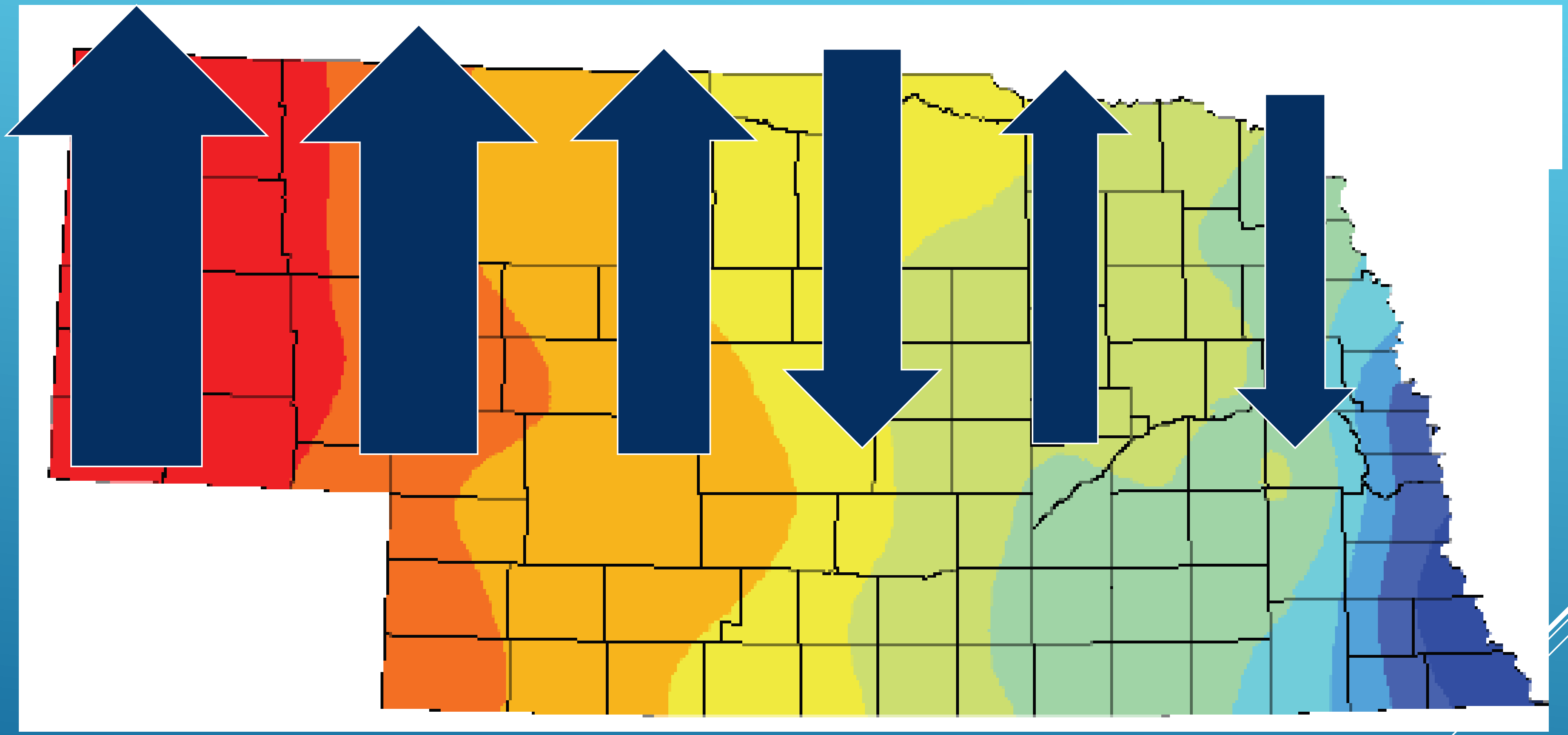
Growing season
PET = 34.8

Corn
ETa = 24.9 in

Annual
precipitation
22.9 in

Soybean
ETa = 22 in

Growing season
precipitation
15.0 in



Statewide average soybean NIR = 9.0 ± 4.9 in
Statewide average corn NIR =11.4 ± 5.52 in
There is 1.2 in decrease in annual precipitation for every 25 mile going from east to west
There is between 0.70 and 5.2 in decrease in annual precipitation for every 329 ft increase in elevation
There is about 1.85 in increase in annual PET for every 329 ft increase in elevation

These circumstances motivated scientists and seed companies in the USA and around the world to develop new drought-tolerant hybrid technologies and other technologies to encounter negative impacts of climate change.

While drought-tolerant hybrid technologies have been suggested to be superior to conventional hybrids, water use efficiency (CWUE, IWUE) and yield response of these hybrids under different irrigation strategies and locations have not been sufficiently researched.

Draught-Resistance Maize Hybrid Research Objectives:

(i) Measure grain yield of drought-tolerant and conventional maize hybrids under different irrigation levels, plant populations, and climates.

(ii) Measure and compare crop production functions for drought-tolerant and conventional maize hybrids under different irrigation levels, plant populations, and climates.

(iii) Measure and compare CWUE and IWUE for drought-tolerant and conventional maize hybrids under different irrigation levels, plant populations, and climates.

Materials and Methods

Field experiments were conducted during 2010–2012 growing seasons at four of University of Nebraska–Lincoln research sites across the state which include different soil types and climate conditions.

Site description and experimental design:

Site	Coordinates	Elevation, m	Soil Type	Field Capacity $m^3\ m^{-3}$	Wilting Point $m^3\ m^{-3}$	Irrigation methods	Climate
SCAL, Clay Center	44.6º N 98.1º W	552	Hastings silt loam	0.34	0.14	Linear move	sub-humid and semi-arid
PHREC, Concord	42.6º N 97º W	445	Blenden sandy loam	0.23	0.10	SDI	sub-humid
WCREC, North Platte	41.1ºN 100.8ºW	861	Cozad silt loam	0.29	0.11	SDI	semi-arid
MAL, Scottsbluff	41.9º N 103.7ºW	1098	Silt loam	0.26	0.11	SDI	semi-arid

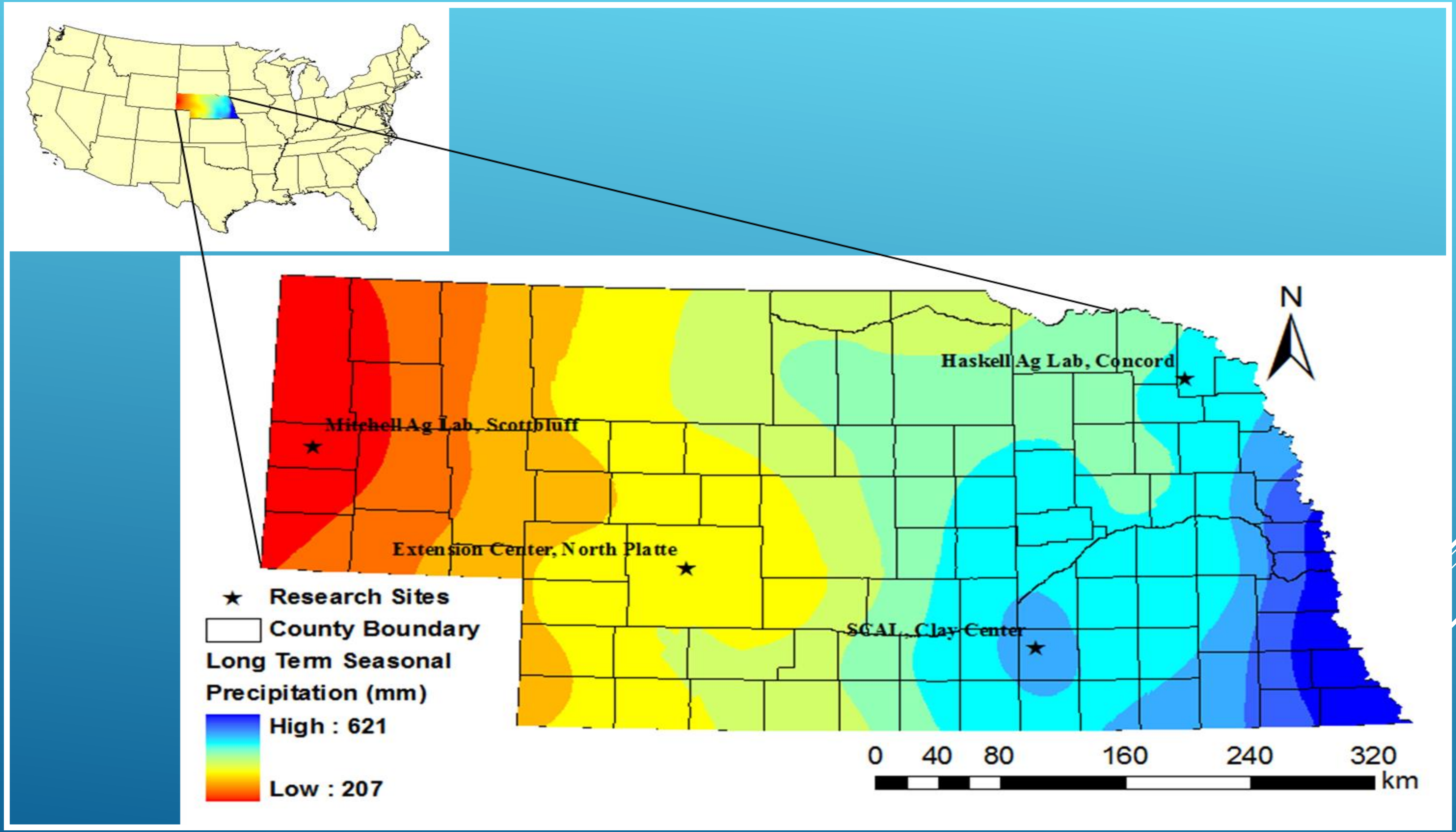
Four Pioneer corn hybrids, two plant populations (59,300 and 84,000 plants/ha), two irrigation strategies (FIT and ECOT), and rainfed condition (RF).

The experiments were split–split plot design with 3–4 replications.

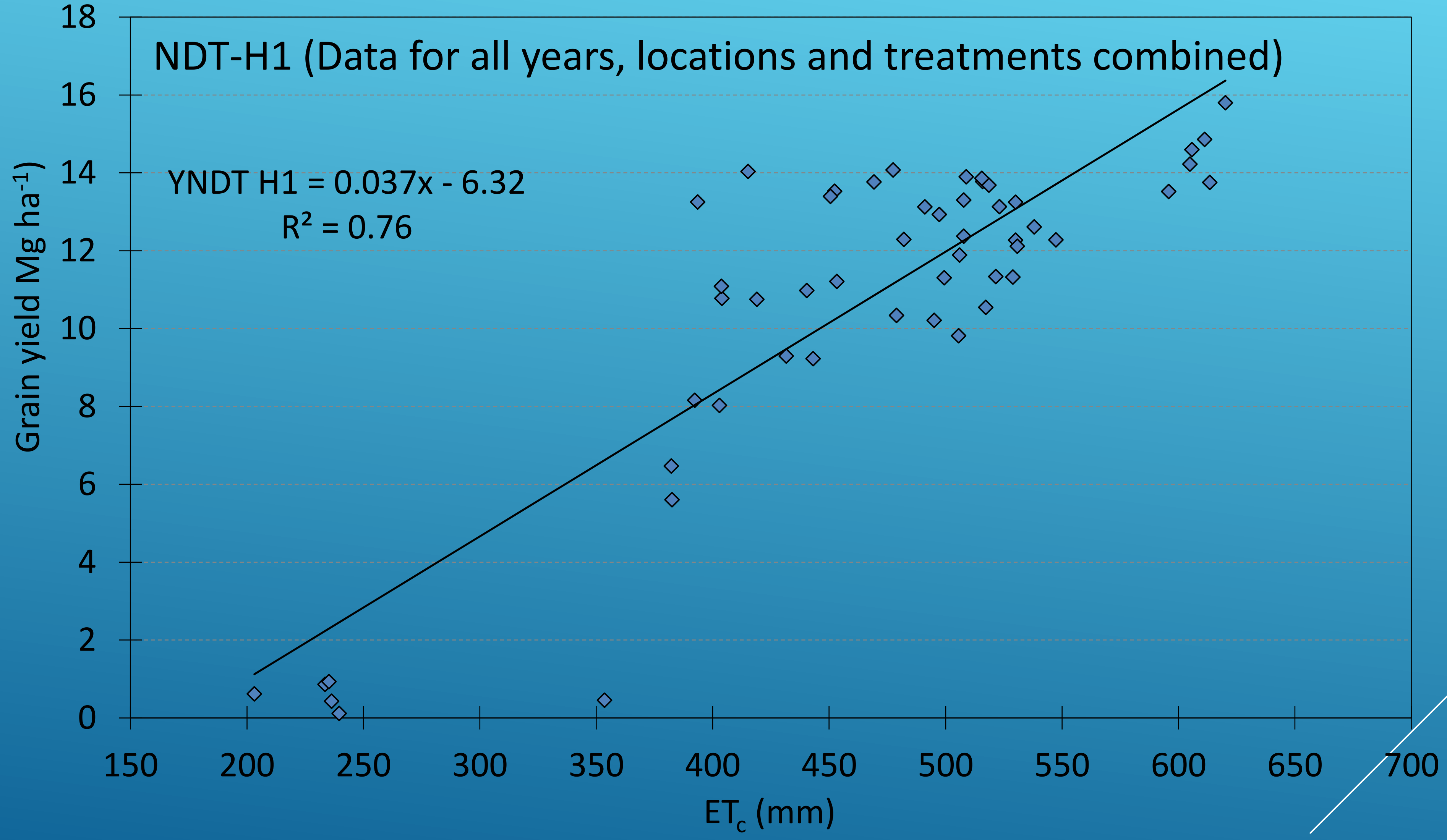
Fertilizer and weed control were applied based on the UNL recommendations.

33P84	H1	P1151HR	H2
P1324HR	H3	PO791HR	H4

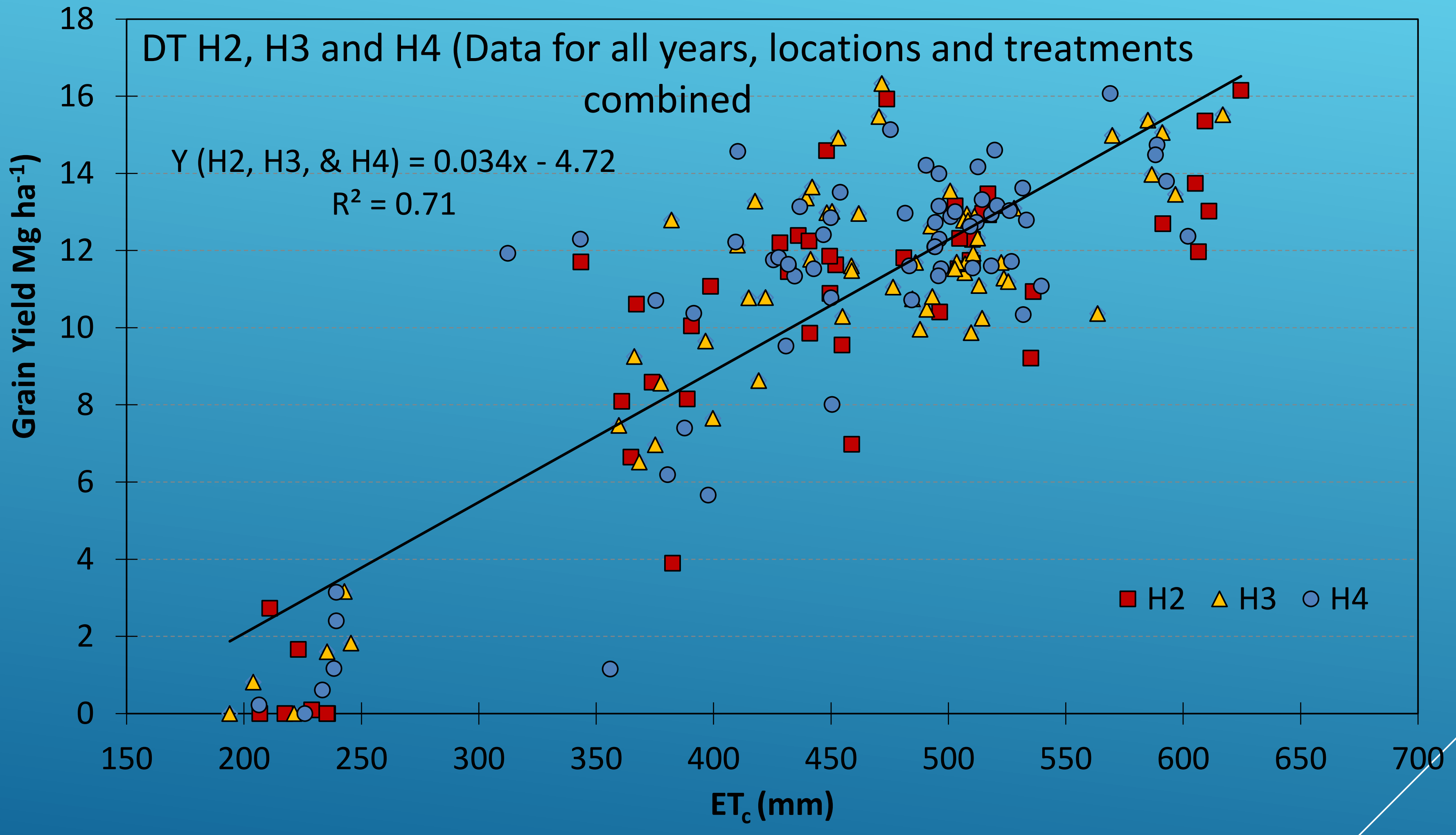
Platform	Hybrid	Pre-commercial (experimental) name	Technology Segment	CRM	Silk CRM	Physiological CRM	GDU's to Silk	GDU's to Physiological Maturity	Grain Drydown,	Stalk Strength	Root Strength	Stress Emergence	Staygreen	Drought Tolerance	High Residue Suitability	Ear Flex	Test Weight	Plant Height	Ear Height	Mid-Season Brittle Stalk	Husk Cover	Gray Leaf Spot	Northern Leaf Blight	Southern Leaf Blight	Goss's Wilt	Stewart's Wilt	Anthracnose Stalk Rot	Head Smut	Fusarium Ear Rot	Gibberella Ear Rot	Diplodia Ear Rot	Common Rust
33P83	33P84 (H1)	-	HX1,LL,RR2	111	115	106	1430	2550	8	6	5	7	4	6	S	6	7	8	6	5	4	4	4	6	6	-	3	4	4	5	5	7
P1151	P1151HR (H2)	X08A236HR	HX1,LL,RR2	111	106	107	1320	2580	6	5	7	5	6	9	S	6	5	5	4	7	6	4	5	-	6	-	3	2	4	3	4	-
P1324	P1324HR (H3)	-	HX1,LL,RR2	113	106	114	1320	2760	6	5	6	5	5	9	S	7	5	3	4	7	8	5	5	-	6	-	4	2	7	4	6	-
P0791	P0791HR (H4)	X7M326TR	HX1,LL,RR2	107	103	104	1280	2500	5	6	3	5	7	9	S	6	4	5	4	6	6	5	5	-	7	6	4	7	5	4	5	-


Haskell Ag Lab, Concord
Mitchell Ag Lab, Scottbluff
Extension Center, North Platte
SCAL, Clay Center
N
Research Sites
County Boundary
Long Term Seasonal
Precipitation (mm)
High : 621
Low : 207
0 40 80 160 240 320
km

Year	Treatment	*H	Population	Rainfall (mm)	Irrigation (mm)	**Grain Yield (Mg ha^{-1})	**ET$_c$ (mm)	CWUE (kg m^{-3})
	***RFT	1	high	483	0	5.8 f	-	-
2010			low	483	0	8.2 de	-	-
		2	high	483	0	7.0 e	458	1.52
			low	483	0	8.6 dc	373	2.30
		3	high	483	0	7.7 de	399	1.91
			low	483	0	8.6 dc	377	2.27
		4	high	483	0	8.0 de	450	1.78
			low	483	0	8.0 de	-	-
	FIT	1	high	483	152	10.4 ab	-	-
			low	483	152	9.5 dc	-	-
		2	high	483	152	10.9 ab	536	2.04
			low	483	152	9.2 dc	535	1.72
		3	high	483	152	11.2 a	525	2.13
			low	483	152	10.4 abe	563	1.84
		4	high	483	152	11.1 ab	539	2.05
			low	483	152	10.3 bce	531	1.94
2012	RFT	1	high	219	0	5.6 j	382	1.47
			low	219	0	6.4ij	382	1.69
		2	high	219	0	6.6 hi	364	1.82
			low	219	0	8.1 g	360	2.24
		3	high	219	0	6.9 ghi	375	1.86
			low	219	0	7.4 gh	359	2.08
		4	high	219	0	6.1 ij	380	1.63
			low	219	0	7.4 gh	387	1.91
	****ECOT	1	high	219	67	10.9 def	440	2.49
			low	219	67	10.7 def	419	2.57
		2	high	219	67	9.8 ef	441	2.24
			low	219	67	9.5 f	425	2.10
		3	high	219	67	10.7 def	415	2.60
			low	219	67	10.3 def	455	2.26
		4	high	219	67	11.6 cd	431	2.70
			low	219	67	11.3 de	434	2.61
	*****FIT	1	high	219	148	14.0 ab	477	2.95
			low	219	148	13.4 bc	450	2.97
		2	high	219	148	15.9 a	473	3.36
			low	219	148	14.6 ab	448	3.26
		3	high	219	148	16.3 a	471	3.46
			low	219	148	15.5 ab	470	3.29
		4	high	219	148	15.1 ab	475	3.18
			low	219	148	14.2 ab	490	2.90



NDT-H1 (Data for all years, locations and treatments combined)
YNDT H1 = 0.037x - 6.32
R² = 0.76
Grain yield Mg ha-1)
ETc (mm)
0
2
4
6
8
10
12
14
16
18
150
200
250
300
350
400
450
500
550
600
650
700



DT H2, H3 and H4 (Data for all years, locations and treatments combined
Y (H2, H3, & H4) = 0.034x - 4.72
R² = 0.71
Grain Yield Mg ha-1)
ETc (mm)
H2
H3
H4
0
2
4
6
8
10
12
14
16
18
150
200
250
300
350
400
450
500
550
600
650
700

Results

- Generally, DT hybrids performed superior to the NDT hybrid not only in dry years, but also in average and above average rainfall years. The performances of the DT hybrids were stronger in drier years; and much stronger, especially with low PPD in the driest year in 2012 at the driest location (Scottsbluff).

- There were significant differences ($P<0.05$) between the ET_c values for some hybrids across three irrigation treatments.

- In most cases, DT H3 resulted in greater grain yield than the NDT H1 and other DT hybrids; and, DT hybrids had lower ET_c in different irrigation levels and PPDs than the NDT hybrid in both locations.

Results

- All hybrids exhibited a linear and strong yield response to increasing ET_c in all years at both locations with positive slopes in all cases. Generally, DT hybrids produced more grain yield per unit of ET_c in drier conditions at PHREC.
- For example, at WCREC, the average ET_b values (average of all three years) for the high PPDs were 299, 294, 277 and 259 mm for NDT H1, DT H2, DT H3 and DT H4 hybrids, respectively, with as much as 40 mm difference between NDT and DT hybrids (H1 vs. H4).
- There were differences in IWUE and CWUE response between the treatments at both locations with DT hybrids generally having greater IWUE and CWUE values than the NDT hybrid.

How do we adopt/implement technologies in production fields to enhance agricultural productivity in a changing climate?

- • Effective agricultural practices that can aid in encountering some of the negative impacts of change in climate variables must be researched, developed, demonstrated and effective education programs must be conducted to enable adoption of these strategies in production fields.
- • Technology implementation in agriculture and natural resources and water resources must be accomplished to adopt climate impacts on agriculture to enhance productivity. It is a difficult task, but can be done.
- • The associated policy and decision-makers should also engage in developing these strategies so that research and development and policy and decision-making processes can be established simultaneously.

United States Senate

United States House of Representatives

Education!   Education!   Education!

NAWMN demonstration and technology implementation sites


06 13 2006





06 13 2006


Water for Food
NEBRASKA WATER CENTER


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


EXTENSION

Thank you!

"Science is the father of knowledge, but opinion breeds ignorance."
Hippocrates, 460 BC – 370 BC.

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