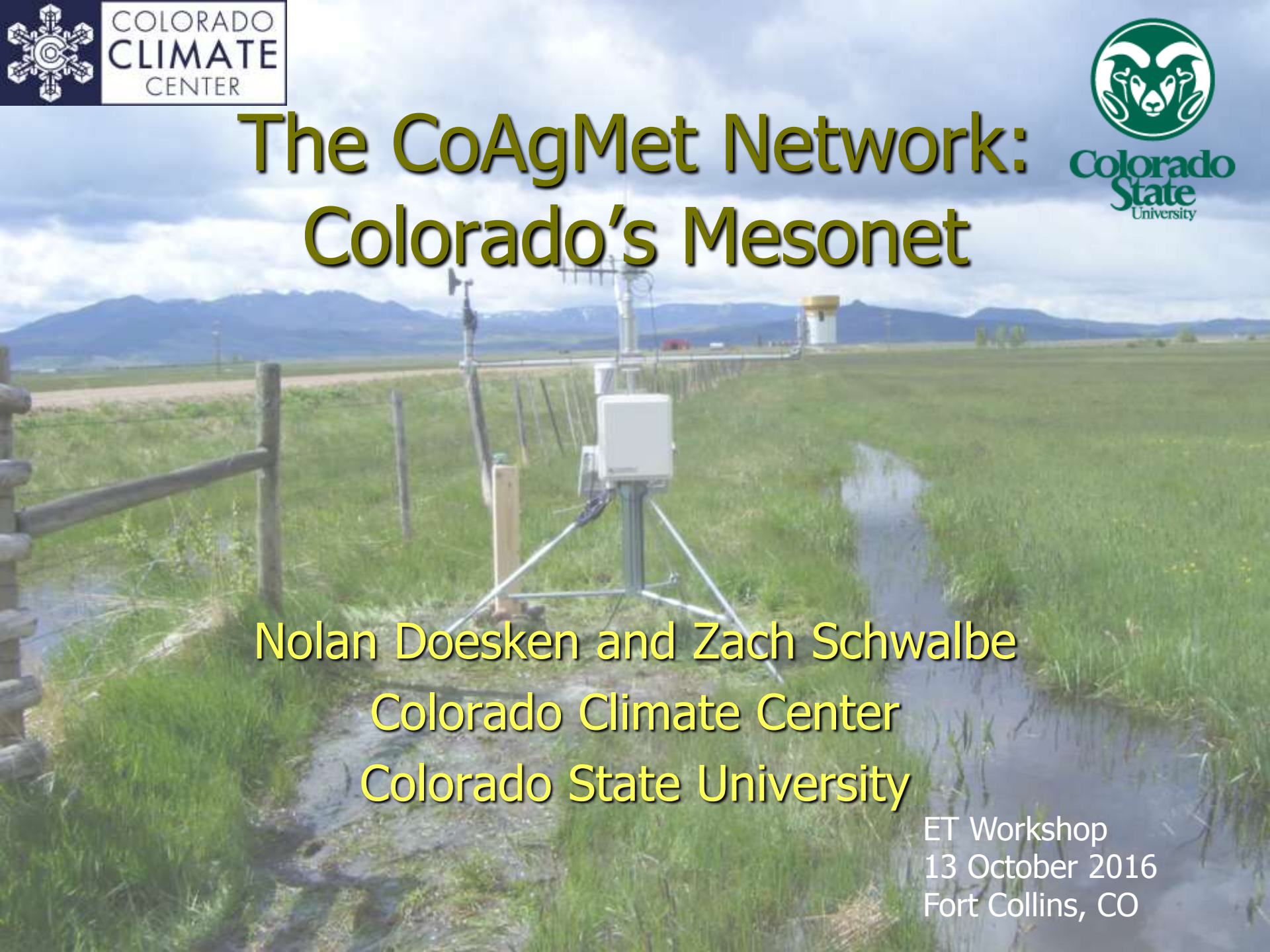
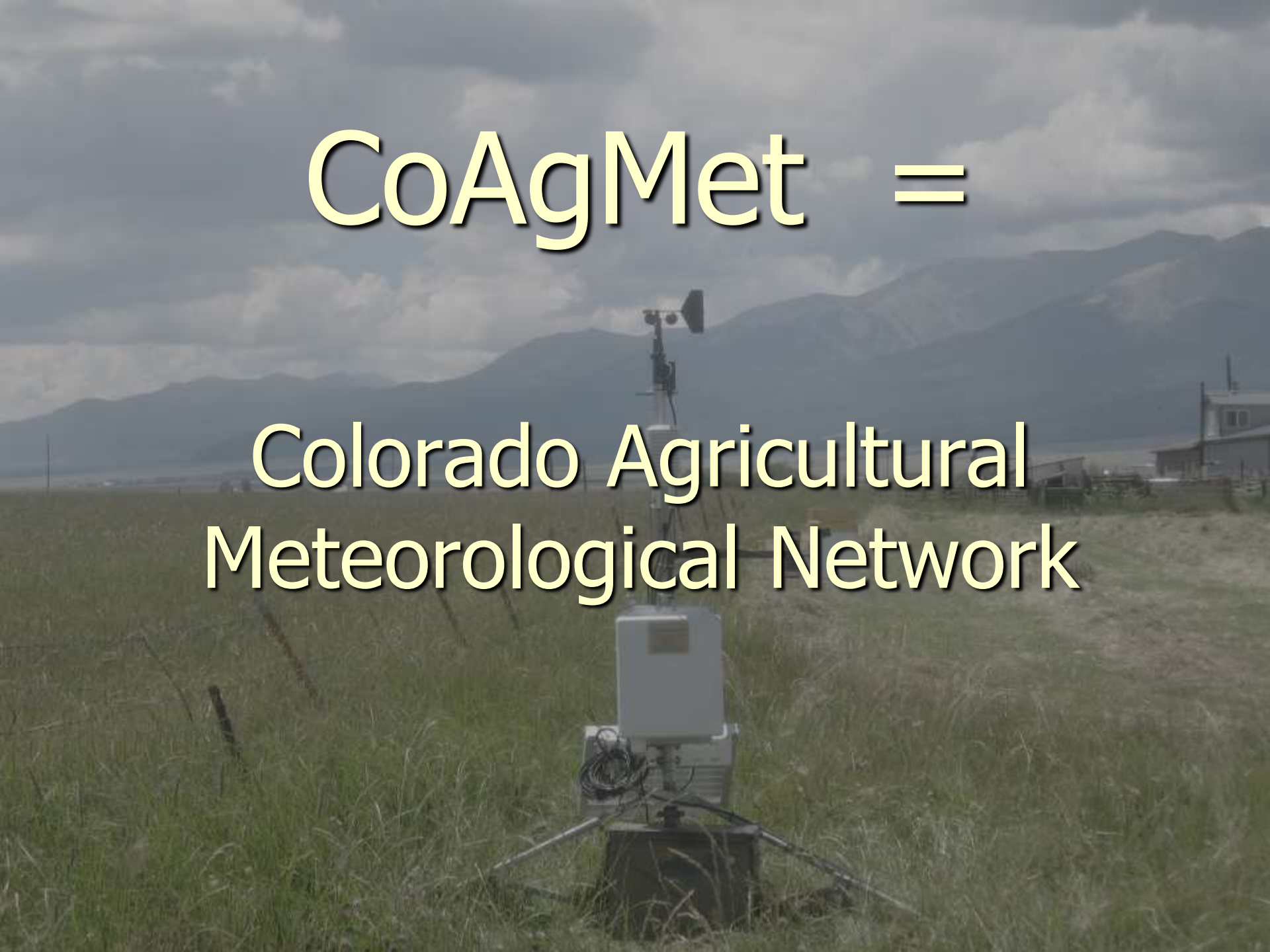


The CoAgMet Network: Colorado's Mesonet

Nolan Doesken and Zach Schwalbe
Colorado Climate Center
Colorado State University

ET Workshop
13 October 2016
Fort Collins, CO


CoAgMet =
Colorado Agricultural
Meteorological Network

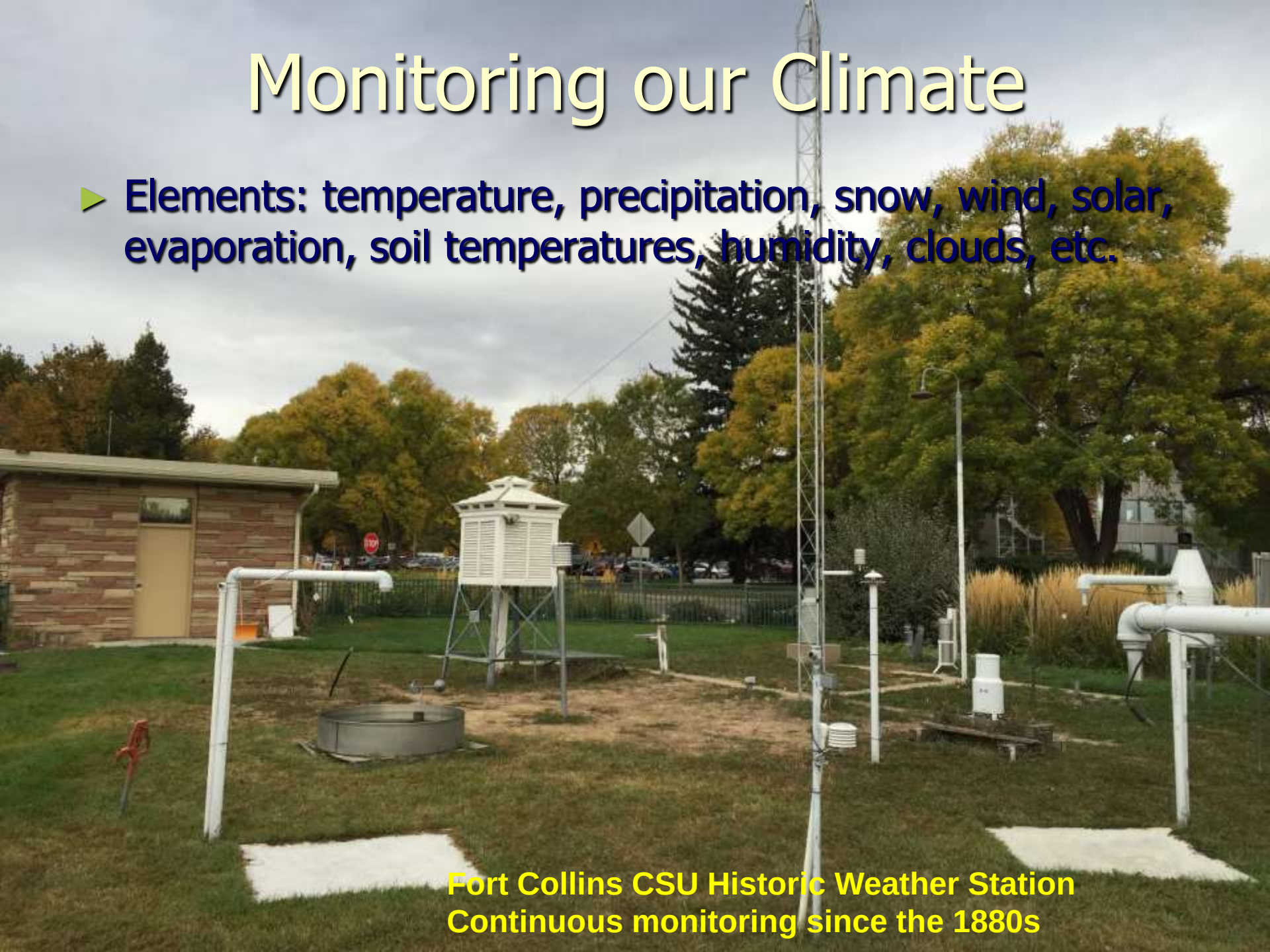
The NWS Cooperative Network is the only source of basic climate information (daily measurements of temperature and precipitation) that covers the entire country down to the local county scale with 120+ years of continuous observations.

Approximately 5000 daily max/min temperature stations, 8000 daily precipitation stations, 3000 automated hourly precipitation stations.


Thanks to the National Weather Service for faithfully maintaining the Cooperative Observer Network since 1890
Our historic baseline for temperature and precipitation
Photo by Christopher Davey

Monitoring our Climate

- Elements: temperature, precipitation, snow, wind, solar, evaporation, soil temperatures, humidity, clouds, etc.



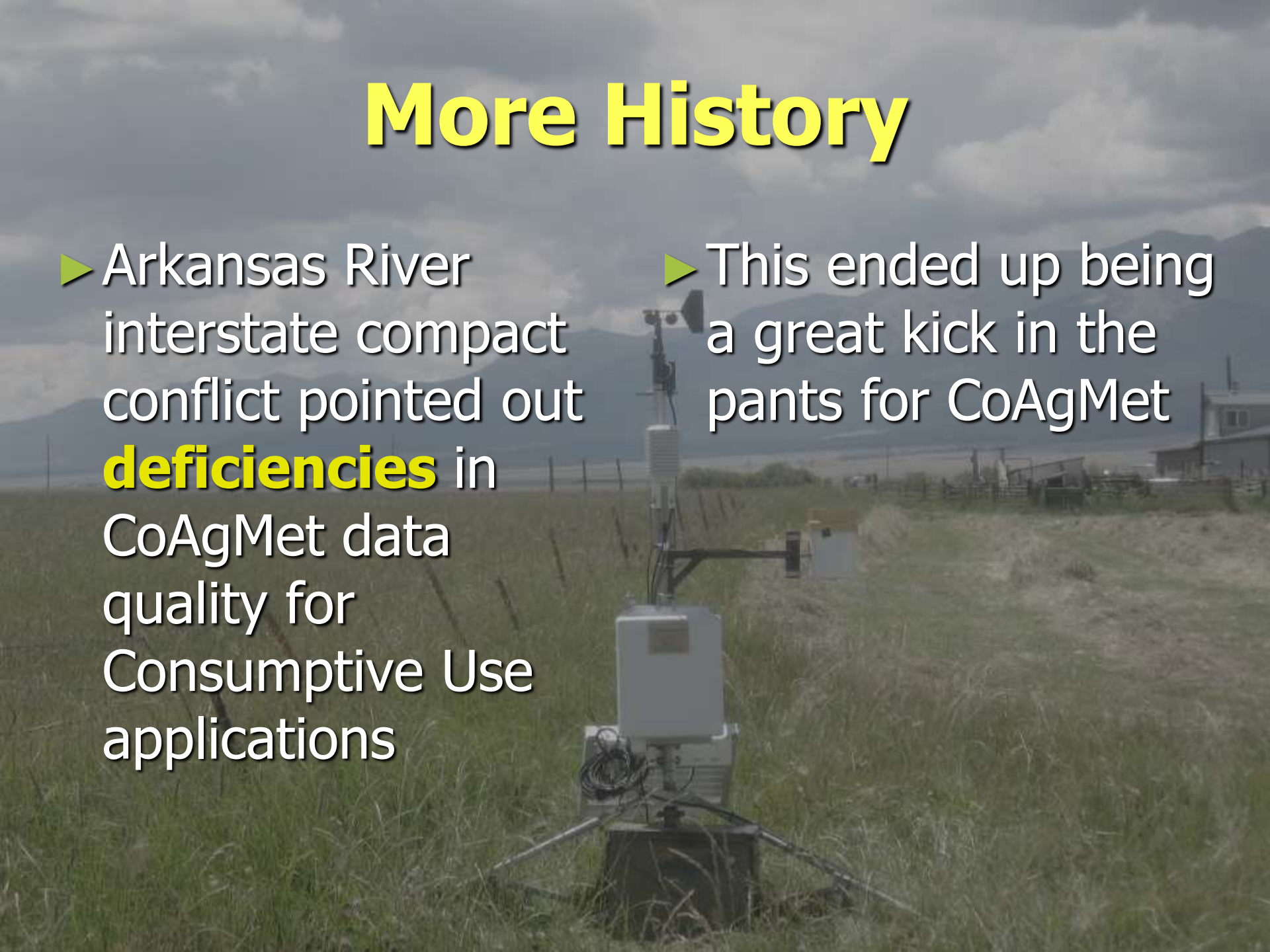
Fort Collins CSU Historic Weather Station
Continuous monitoring since the 1880s

History

- In the early 1990's, CSU extension plant pathologists and ARS irrigation engineers **(Harold Duke)** teamed up to collect agricultural weather data.
- Standard instruments and data collection platform were selected and a small network of stations was deployed in fully irrigated agriculture.
- USDA ARS turned over data ingest and management to the Colorado Climate Center later 1990s.

More History

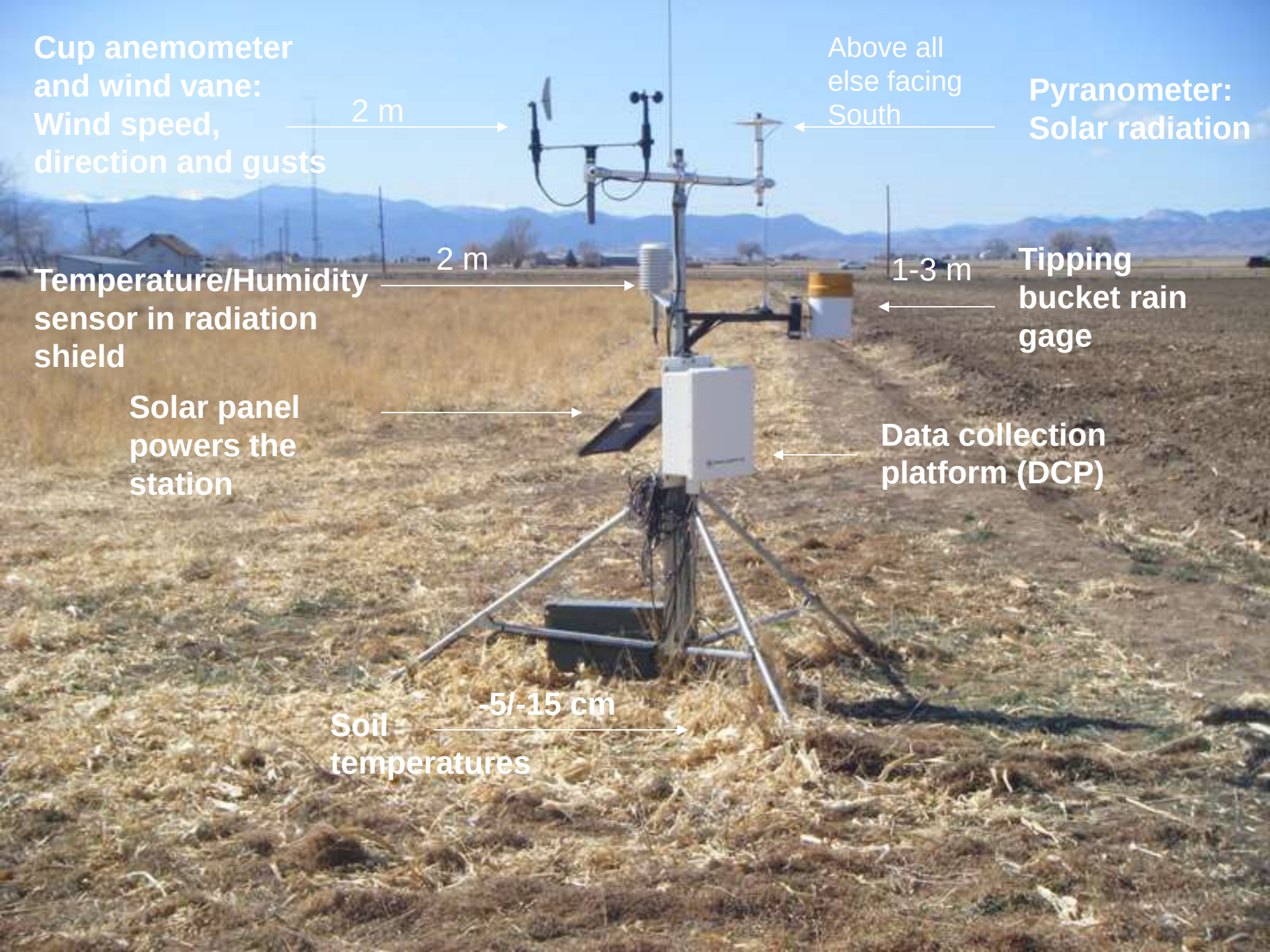
- Arkansas River interstate compact conflict pointed out **deficiencies** in CoAgMet data quality for Consumptive Use applications
- This ended up being a great kick in the pants for CoAgMet



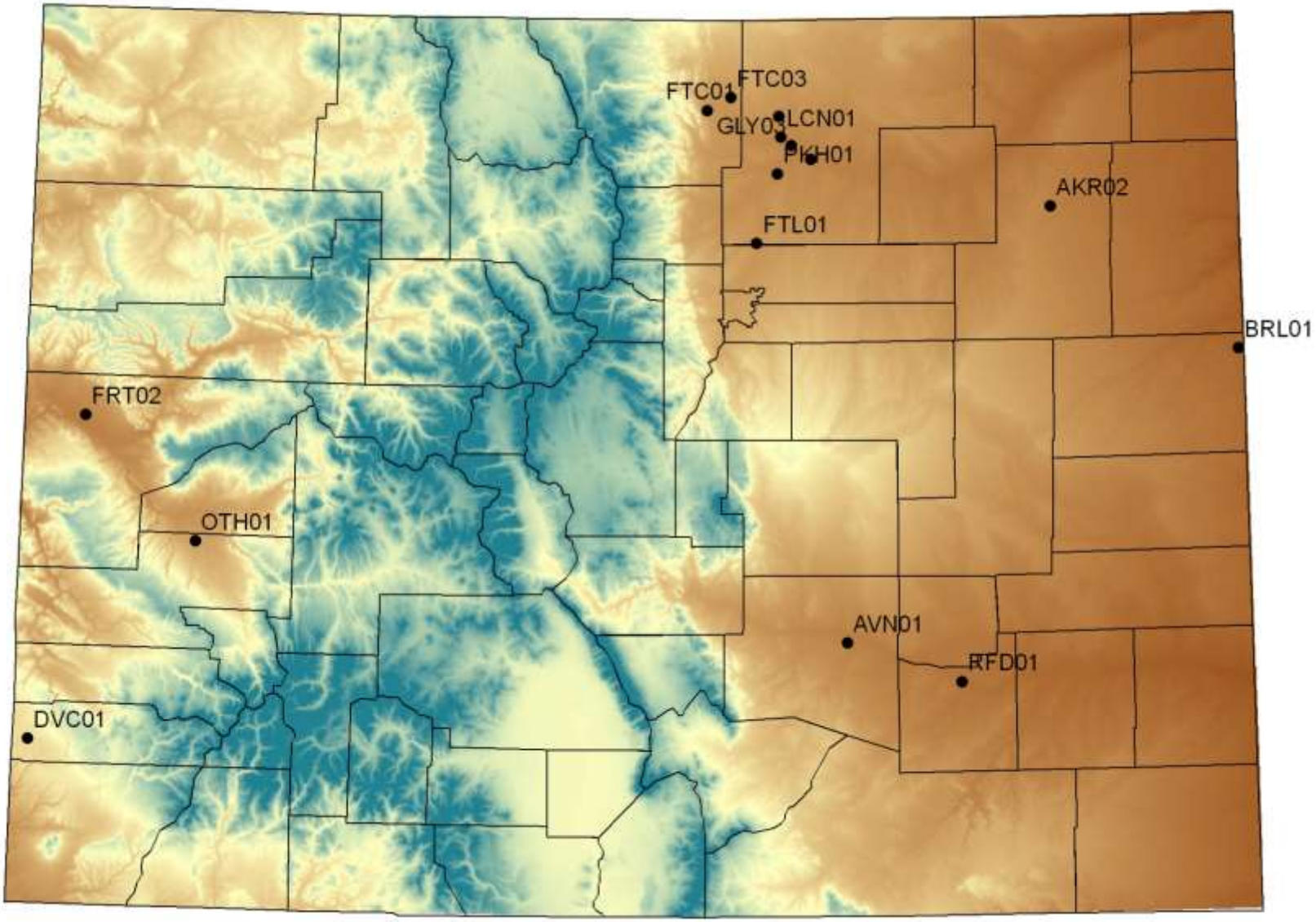
Colorado Climate Center's role

- Coodination, data management, web support
- We hosted annual meetings of key partners and data users – set priorities, secure commitments, prepare proposals (rarely funded but we persisted)
- We now run the network including station maintenance, product development, bring in funding, etc.

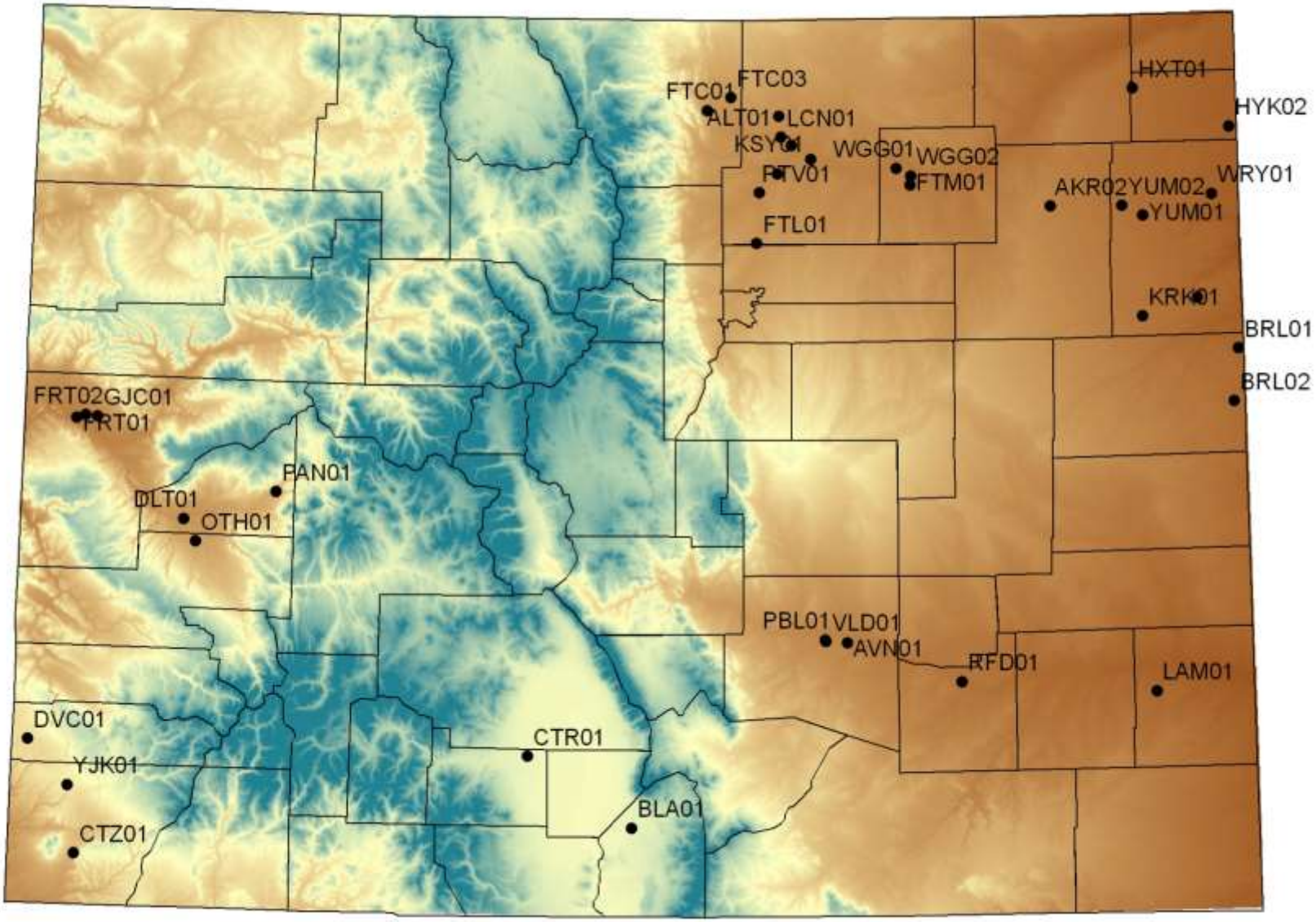
What do the stations measure?


Cup anemometer and wind vane: Wind speed, direction and gusts
2 m
Above all else facing South
Pyranometer: Solar radiation
Temperature/Humidity sensor in radiation shield
2 m
1-3 m
Tipping bucket rain gage
Solar panel powers the station
Data collection platform (DCP)
Soil temperatures
-5/-15 cm

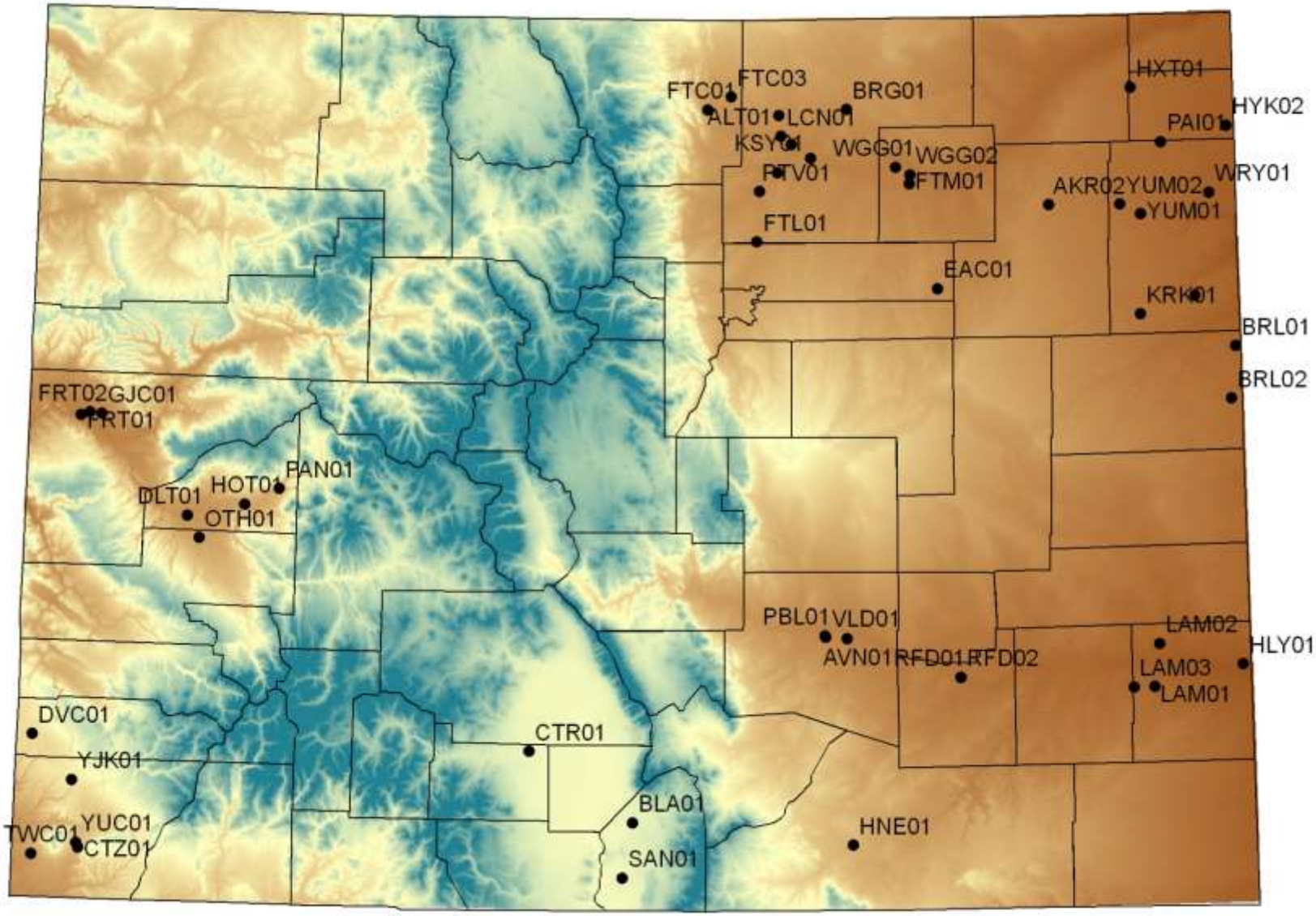
CoAgMet 1992



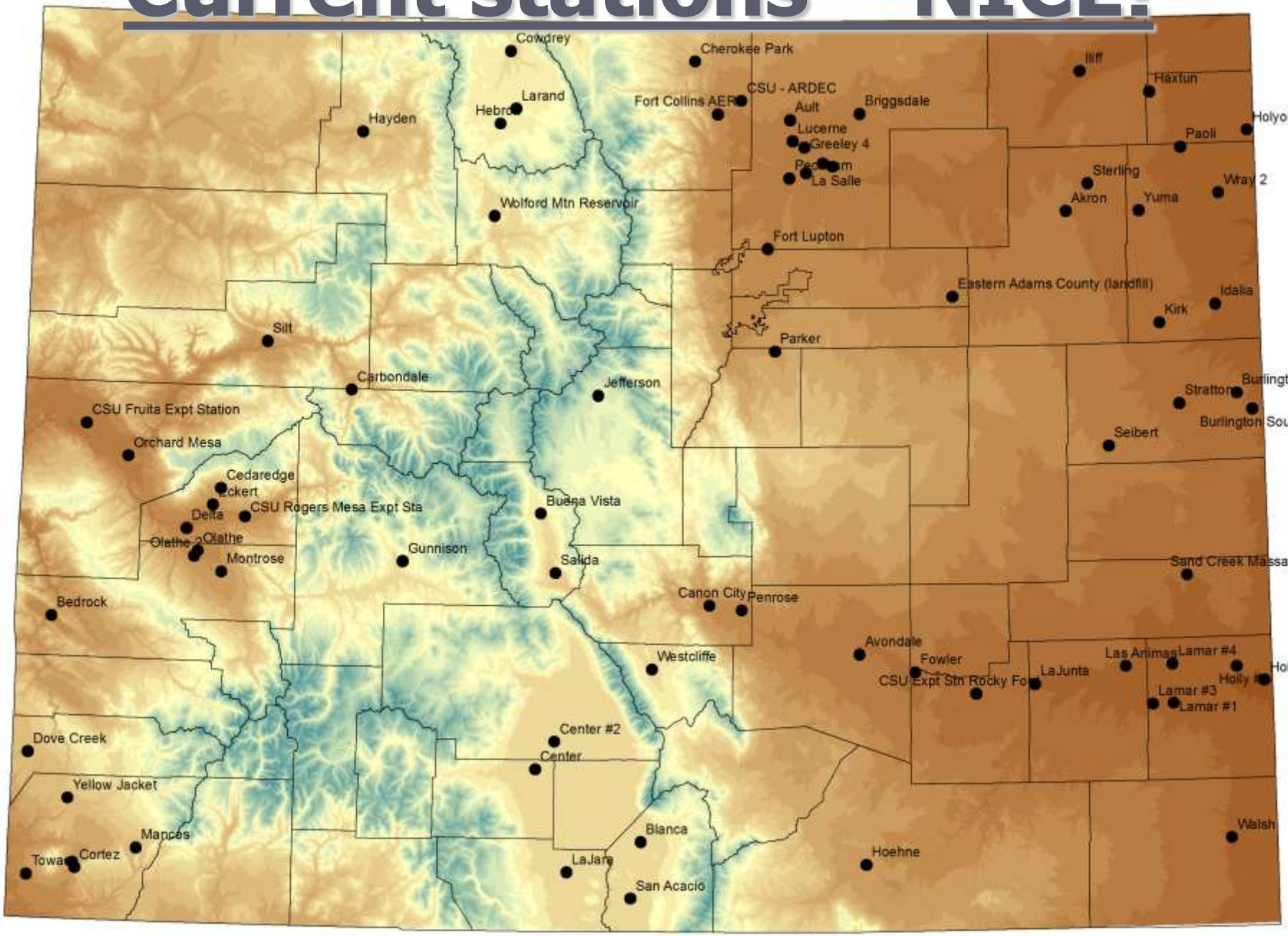
CoAgMet 1997



CoAgMet 2002



Current stations – NICE!



How did we grow

- Many Partners: NCWCD, Extension, NRCS, Commodities groups, Conservation Districts More recently –Basin Roundtables, other water districts

- For nearly 20 years we used a model of "shared benefits / shared responsibilities" field techs, year-end funds, donations

Supporters

- Agriculture Experiment Station
- Station Sponsors
  - Water Conservation Districts
  - CSU Extension Offices
  - Basin Roundtables
  - Municipalities
- Arkansas River Compact Administration

Support

- CWCB (second year of support for improving and enhancing the network, products and services)
- National Weather Service "National Mesonet"

STAFFING

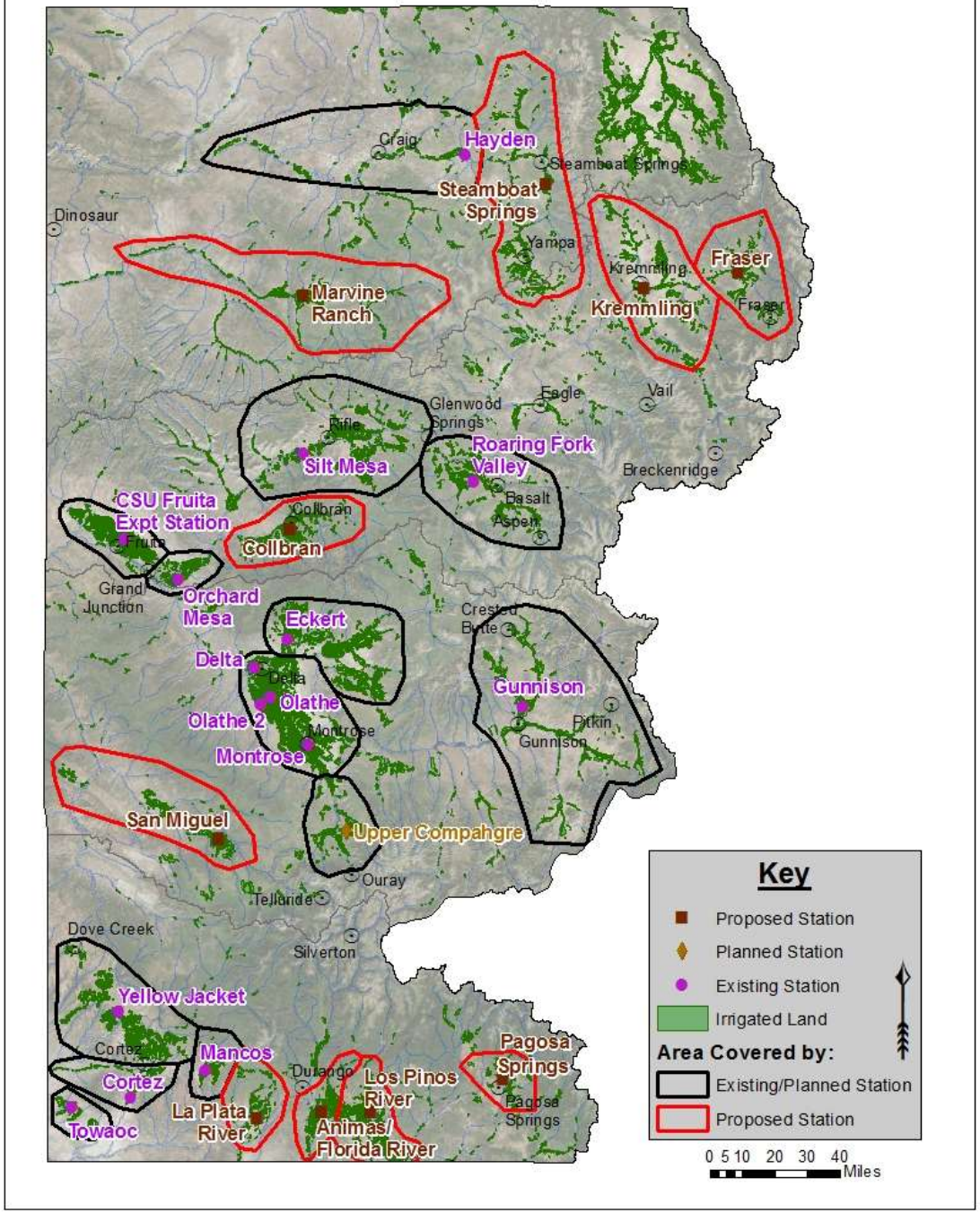
Zach Schwalbe – network management

Lane Simmons – supporting Ark Valley stations

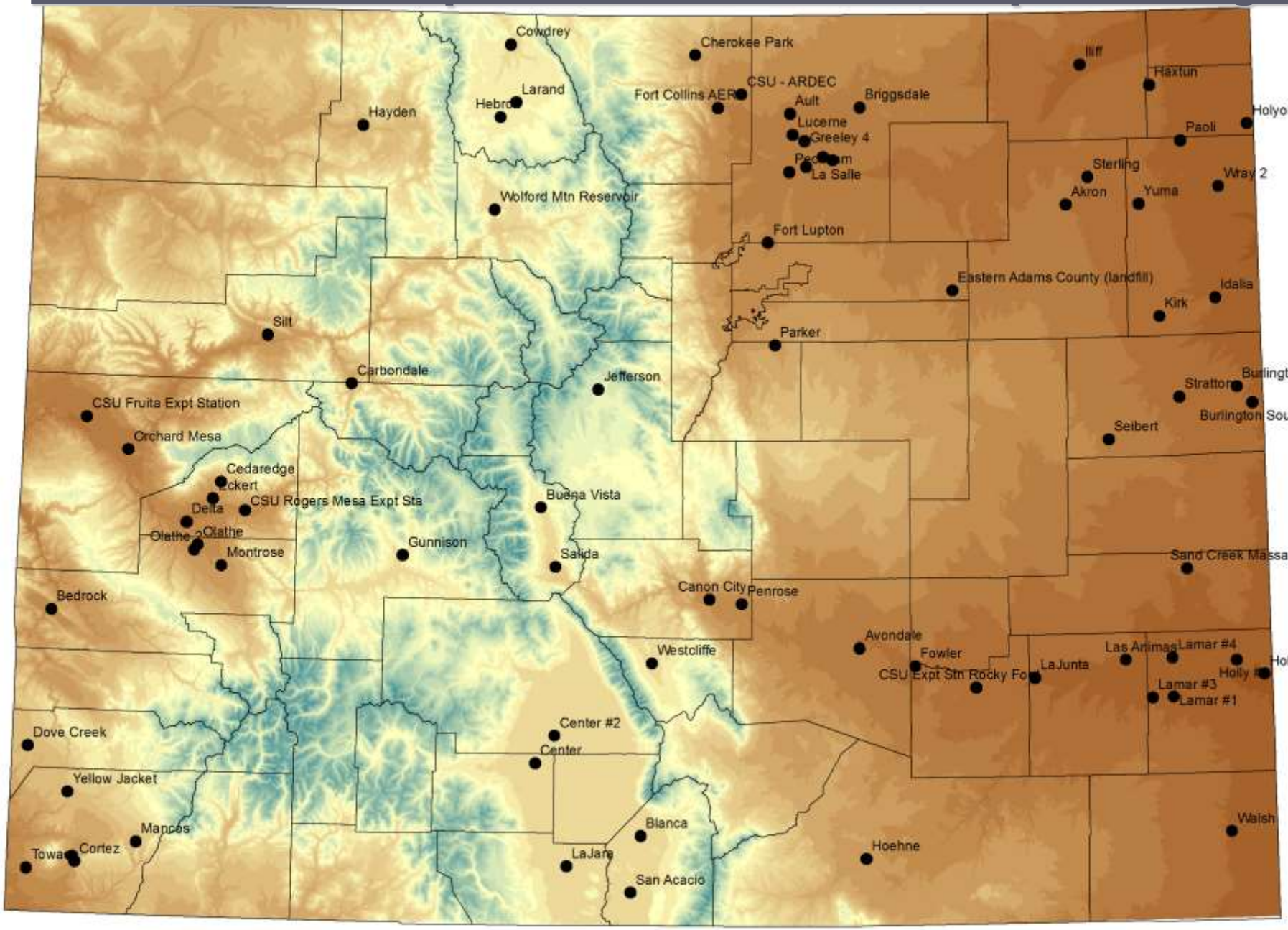
Extension and Research Center staff support as needed in emergencies

2016-17 Expansion

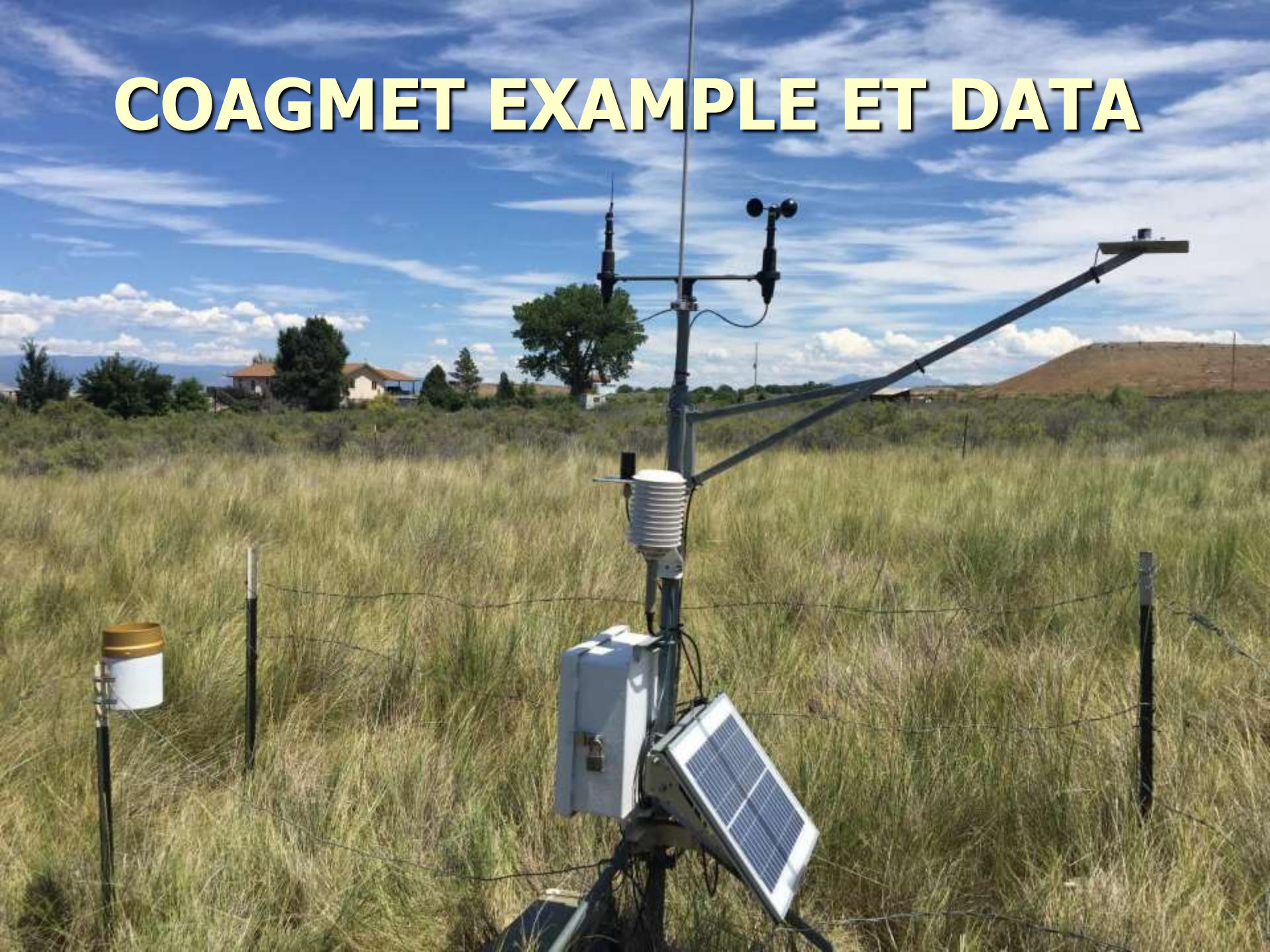
- Expect more stations soon, primarily in the Colorado River Basin (western Colorado) as a part of Upper Colorado River Commission efforts to standardize upper basin states Consumptive Use estimates.
- Stations being purchased and supported by USBR


Craig
Hayden
Steamboat Springs
Steamboat Springs
Dinosaur
Yampa
Kremmling
Fraser
Marvine Ranch
Kremmling
Fraser
Eagle
Vail
Glenwood Springs
Rifle
Roaring Fork Valley
Silt Mesa
Breckenridge
Basalt
Aspen
CSU Fruita Expt Station
Fruita
Collbran
Collbran
Grand Junction
Orchard Mesa
Crested Butte
Eckert
Delta
Delta
Gunnison
Olathe
Olathe 2
Montrose
Pitkin
Gunnison
Montrose
San Miguel
Upper Compahgre
Ouray
Telluride
Dove Creek
Silverton
Yellow Jacket
Cortez
Mancos
Durango
Los Pinos River
Pagosa Springs
Cortez
Pagosa Springs
La Plata River
Towaoc
Animas/ Florida River
Key
Proposed Station
Planned Station
Existing Station
Irrigated Land
Area Covered by:
Existing/Planned Station
Proposed Station
0 5 10 20 30 40
Miles

New stations will provide awesome W. Slope coverage



COAGMET EXAMPLE ET DATA



CoAgMet Homepage

News

- Make a donation to CoAgMet. Choose "Atmospheric Science" in the pull-down menu at the top, and in the "comments" field at the bottom, indicate "Gift is for Colorado Climate Center - new gift fund"
- A variety of data and metadata are available through the Climate Center's Web Services. This link will be useful to those accessing data using scripts. To see the program documentation or to run Web Services, go here.
- It is now possible to extract five minute data for the ARDEC and Cherokee Parks stations using Web Services. For example, to extract summer 2015 temperature and preciptations for ARDEC use:

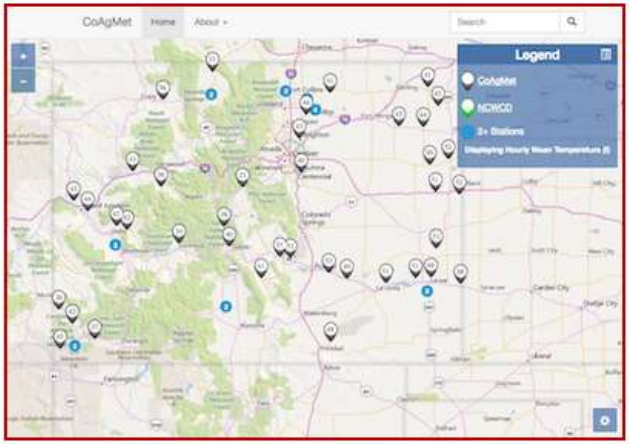
```
http://coagmet.colostate.edu/cgi-bin/web_services.pl?type=five_minute&sids=ftc03&sdate=2015-06-01&edate=2015-08-31&elems=tmean,pp
```

For more information, see the Web Services page.

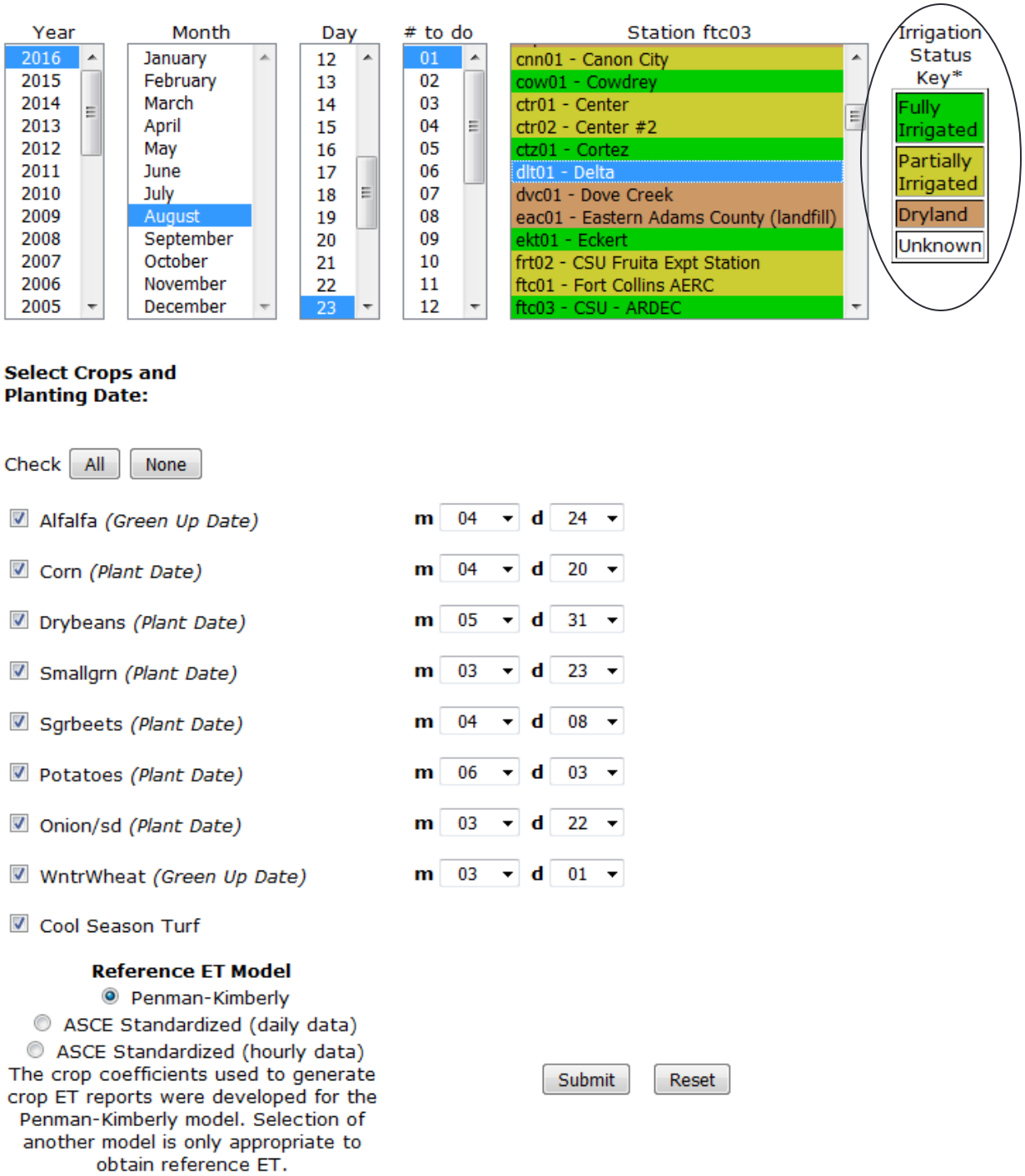
Find older posts here.

- About CoAgMet
  A brief history of how CoAgMet came to be.
- CoAgMet factsheet has useful information on using this page.
- CoAgMet Crop Water Use (ET) Access
  Page for obtaining crop and turf water use information (ET).
- CoAgMet Text Message Service.
  Sign up for our SMS/email message service. You will be able to customize the messages sent to your cell phone (or email address).
- Evapotranspiration Reports
  ETRs are daily reports for selected stations by region.
- Station Description
  A description of a typical CoAgMet station.
- Station Index
  Metadata on all of the stations on the CoAgMet network.
- Monthly Summaries
  Interactive access to the daily data set for a particular station and selected months.
- Daily Summaries (all stations)
  Daily summary files are formatted to display selected parameters for all stations.

CoAgMet Mapping and Metadata by eRAMS



Select from a number of crop types.



Station:Delta
Location:3 mi W Delta
Elevation:5010
Longitude:108.118
Latitude:38.7342

Crop Evapotranspiration in Inches

Date	Alfalfa	Corn	Drybeans	Smallgrn	Sgrbeets	Potatoes	Onion/sd	WntrWheat	Turf	RefET	Precip
06/25/2016	0.38	0.32	0.25	0.22	0.29	0.15	0.29	0.08	0.26	0.38	0.00
06/26/2016	0.38	0.33	0.26	0.21	0.29	0.16	0.29	0.08	0.25	0.38	0.00
06/27/2016	0.38	0.33	0.28	0.19	0.30	0.17	0.29	0.08	0.26	0.38	0.00
06/28/2016	0.30	0.27	0.23	0.14	0.24	0.14	0.23	0.07	0.20	0.30	0.00
06/29/2016	0.31	0.28	0.24	0.14	0.26	0.15	0.24	0.07	0.21	0.31	0.00
06/30/2016	0.30	0.28	0.25	0.13	0.26	0.15	0.24	0.07	0.21	0.30	0.00
07/01/2016	0.13	0.12	0.11	0.05	0.11	0.07	0.10	0.03	0.09	0.13	0.09
07/02/2016	0.17	0.15	0.14	0.06	0.14	0.08	0.13	0.04	0.11	0.17	0.16
07/03/2016	0.24	0.22	0.20	0.09	0.21	0.12	0.19	0.05	0.16	0.24	0.00
07/04/2016	0.31	0.29	0.28	0.10	0.28	0.17	0.25	0.07	0.21	0.31	0.00
07/05/2016	0.33	0.31	0.30	0.10	0.30	0.19	0.27	0.07	0.23	0.33	0.00
07/06/2016	0.40	0.38	0.38	0.10	0.38	0.23	0.32	0.09	0.27	0.40	0.00
07/07/2016	0.36	0.35	0.35	0.08	0.35	0.22	0.29	0.08	0.25	0.36	0.00
07/08/2016	0.34	0.33	0.34	0.08	0.33	0.21	0.27	0.08	0.23	0.34	0.00
07/09/2016	0.35	0.34	0.35	0.08	0.35	0.22	0.28	0.08	0.24	0.35	0.00
07/10/2016	0.40	0.39	0.40	0.09	0.40	0.27	0.32	0.09	0.27	0.40	0.00
07/11/2016	0.41	0.39	0.41	0.09	0.41	0.28	0.33	0.09	0.28	0.41	0.00
07/12/2016	0.37	0.36	0.37	0.08	0.37	0.26	0.30	0.08	0.25	0.37	0.00
07/13/2016	0.37	0.35	0.37	0.08	0.37	0.27	0.29	0.08	0.25	0.37	0.00
07/14/2016	0.34	0.33	0.34	0.07	0.34	0.25	0.27	0.07	0.23	0.34	0.00
07/15/2016	0.32	0.30	0.32	0.07	0.32	0.24	0.25	0.07	0.21	0.32	0.00
07/16/2016	0.40	0.38	0.40	0.09	0.40	0.31	0.32	0.09	0.27	0.40	0.00
07/17/2016	0.34	0.33	0.34	0.07	0.34	0.27	0.27	0.07	0.23	0.34	0.00
07/18/2016	0.31	0.30	0.31	0.07	0.31	0.25	0.25	0.07	0.21	0.31	0.00
07/19/2016	0.23	0.22	0.23	0.05	0.23	0.19	0.19	0.05	0.16	0.23	0.05
07/20/2016	0.27	0.26	0.27	0.06	0.27	0.23	0.22	0.06	0.18	0.27	0.02
07/21/2016	0.24	0.23	0.24	0.05	0.24	0.20	0.19	0.05	0.16	0.24	0.00
07/22/2016	0.26	0.25	0.26	0.06	0.26	0.22	0.21	0.06	0.17	0.26	0.02
07/23/2016	0.30	0.28	0.30	0.06	0.30	0.26	0.24	0.06	0.20	0.30	0.00
07/24/2016	0.30	0.28	0.30	0.07	0.30	0.26	0.24	0.07	0.20	0.30	0.00
07/25/2016	0.28	0.27	0.28	0.06	0.28	0.25	0.23	0.06	0.19	0.28	0.00
07/26/2016	0.26	0.25	0.26	0.06	0.26	0.23	0.21	0.06	0.18	0.26	0.00

ET reports by region

CoAgMet/NCWCD Meteorological Data for 8/23/2016

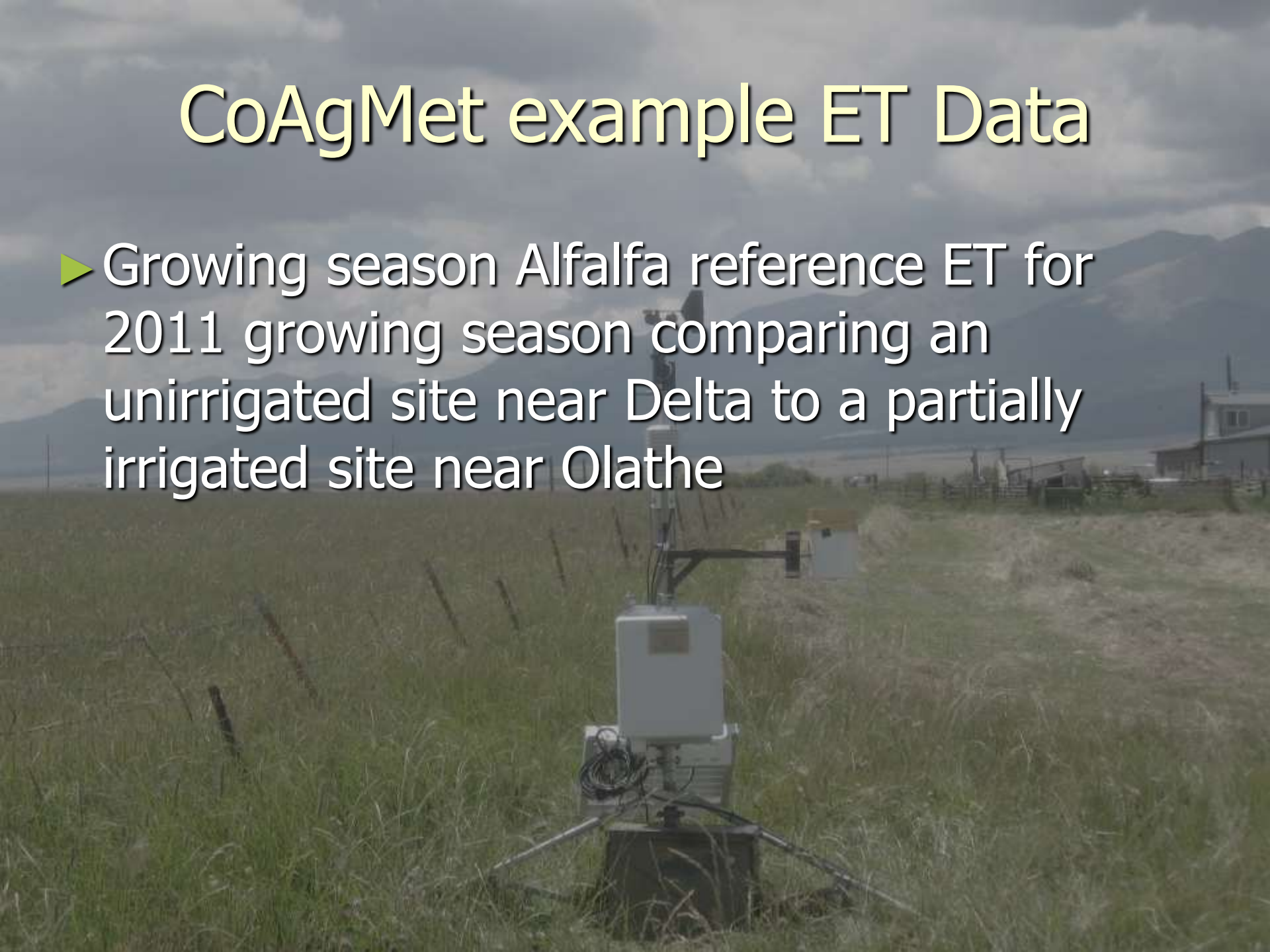
	North Front Range							
	FtColl	ARDEC	HortFm	Lovlnd	Cherpk	Lngmnt	Parker	
HiTemp	90	86	87	86	83	87	84	degF
LoTemp	50	52	49	53	54	53	56	degF
Precip	0.00	0.00	0.00	0.00	0.00	0.00	0.00	in
P/Month	0.28	0.84	0.39	0.26	0.54	0.21	0.06	in
P/Year	7.31	6.52	5.71	7.61	8.68	6.79	6.81	in
WindGst	25.0	18.8	52.4	22.3	22.0	30.9	24.2	mph
Ref ET	0.30	0.23	0.26	0.15	0.24	0.22	0.25	in
GrowDD	2108	2188	2180	2433	2006	2212	2376	degF
5cm Soil	61.0	63.4	m	m	59.7	m	67.6	degF
	Crop Evapotranspiration							
Alfalfa	0.30	0.23	0.26	0.15	0.25	0.22	0.25	in
Corn	0.29	0.21	0.06	0.14	0.20	0.19	0.07	in
Drybeans	0.30	0.23	0.26	0.15	0.25	0.22	0.25	in
Smallgrn	0.07	0.05	0.06	0.03	0.05	0.05	0.06	in
Sgrbeets	0.30	0.23	0.21	0.15	0.24	0.22	0.21	in
Potatoes	0.27	0.21	0.24	0.13	0.22	0.20	0.23	in
Onion/sd	0.24	0.18	0.12	0.12	0.19	0.18	0.11	in
WntrWheat	0.07	0.05	0.26	0.03	0.05	0.05	0.25	in

CoAgMet/NCWCD Meteorological Data for 8/23/2016

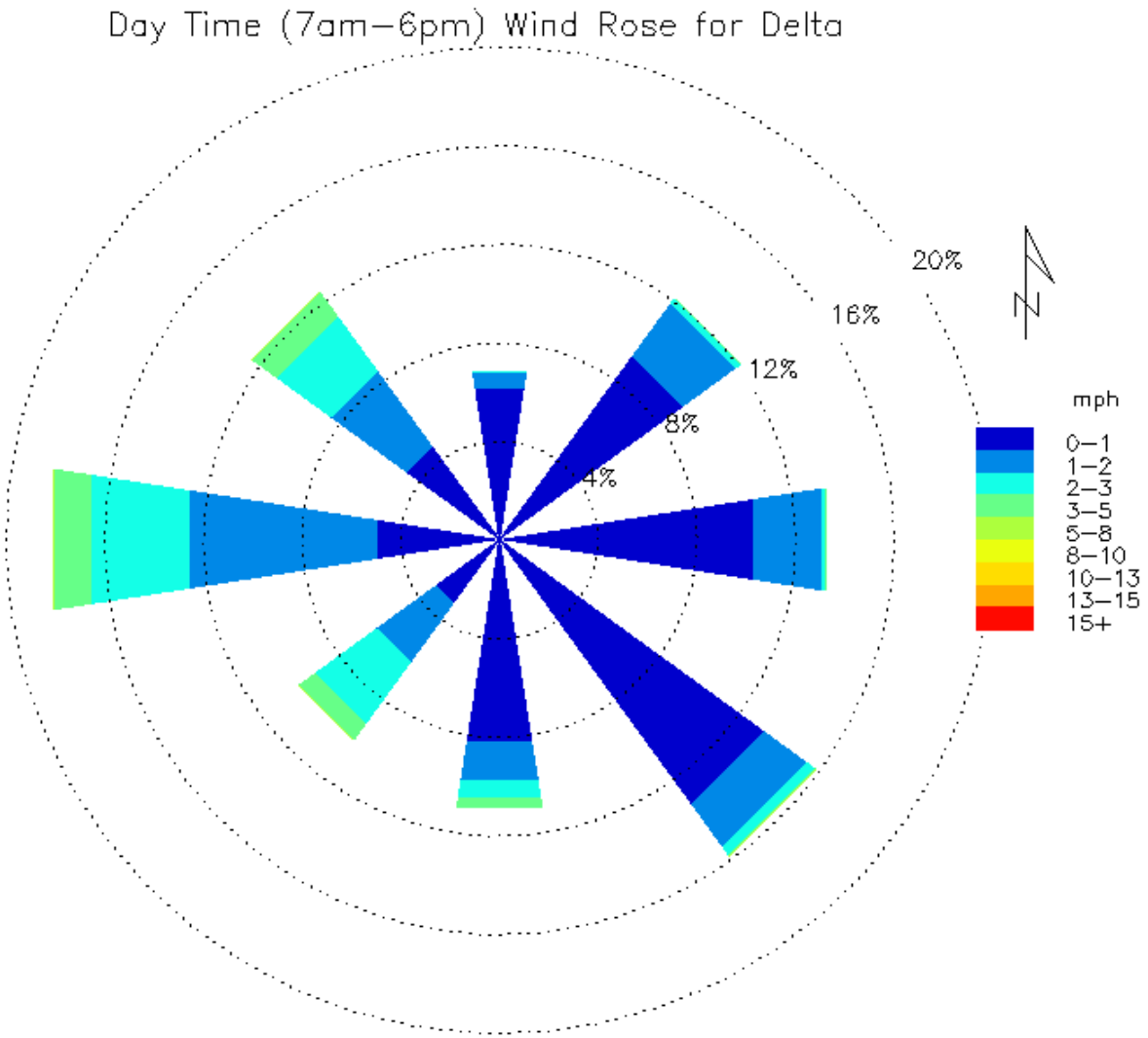
	North Central									
	Peckhm	Kersey	Kersey	Lucern	Greely	Gilcrs	FtLptn	Ault	Brigsd	
HiTemp	90	86	88	86	85	87	86	84	94	degF
LoTemp	49	45	46	48	47	47	58	51	46	degF
Precip	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	in
P/Month	1.42	0.65	0.75	1.21	1.14i	1.49	7.20i	0.25	0.52	in
P/Year	9.28	11.48	10.23	9.83	8.24i	10.06	12.07i	7.09i	7.85	in
WindGst	19.3	21.7	26.5	19.2	15.0	33.2	26.4	24.7	17.5	mph
Ref ET	0.19	0.22	0.25	0.19	0.18	0.21	0.28	0.23	0.29	in
GrowDD	2358	2256	2321	2283	2245	2381	2201	1965	2294	degF
5cm Soil	66.6	63.8	66.8	64.9	62.6	m	73.3	61.9	63.9	degF
	Crop Evapotranspiration									
Alfalfa	0.19	0.22	0.25	0.19	0.18	0.21	0.28	0.23	0.29	in
Corn	0.15	0.19	0.20	0.16	0.16	0.16	0.19	0.21	0.14	in
Drybeans	0.19	0.22	0.25	0.19	0.18	0.21	0.28	0.23	0.29	in
Smallgrn	0.04	0.05	0.06	0.04	0.04	0.05	0.06	0.05	0.06	in
Sgrbeets	0.19	0.22	0.25	0.19	0.18	0.20	0.27	0.23	0.26	in
Potatoes	0.17	0.20	0.23	0.17	0.16	0.19	0.25	0.20	0.26	in
Onion/sd	0.13	0.17	0.18	0.15	0.15	0.15	0.15	0.18	0.13	in
WntrWheat	0.04	0.05	0.06	0.04	0.04	0.05	0.06	0.05	0.16	in

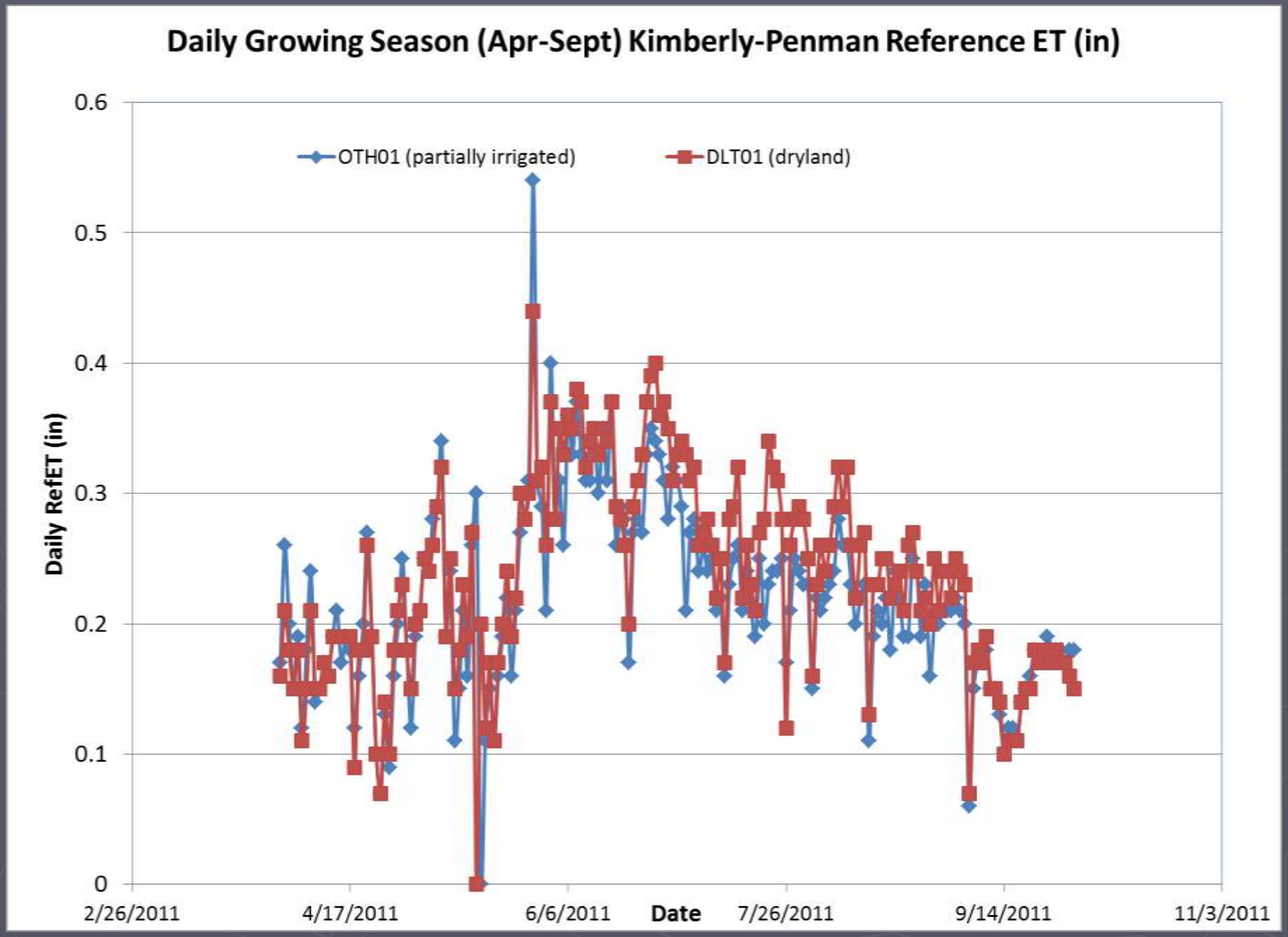
CoAgMet example ET Data

- Growing season Alfalfa reference ET for 2011 growing season comparing an unirrigated site near Delta to a partially irrigated site near Olathe

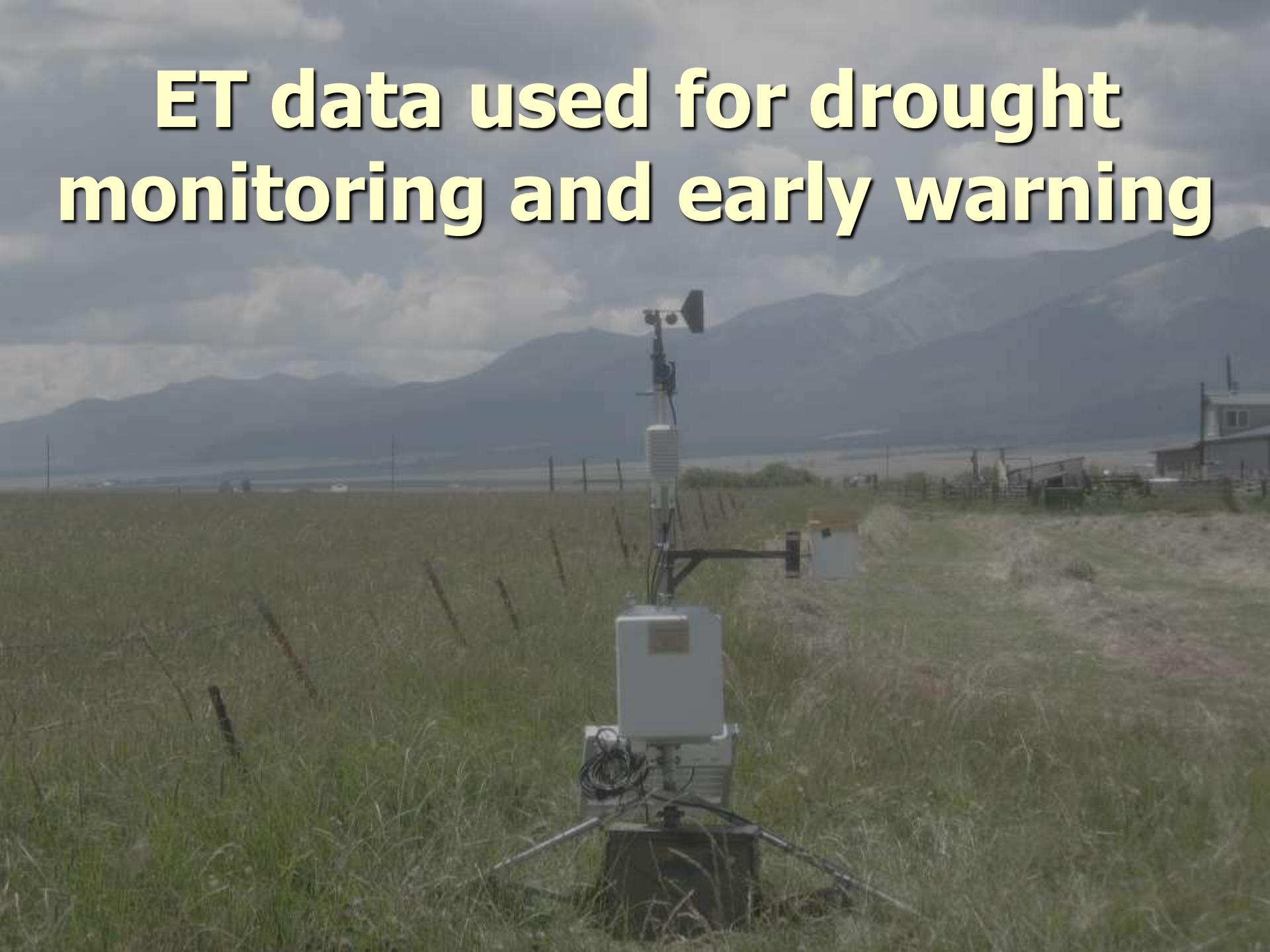


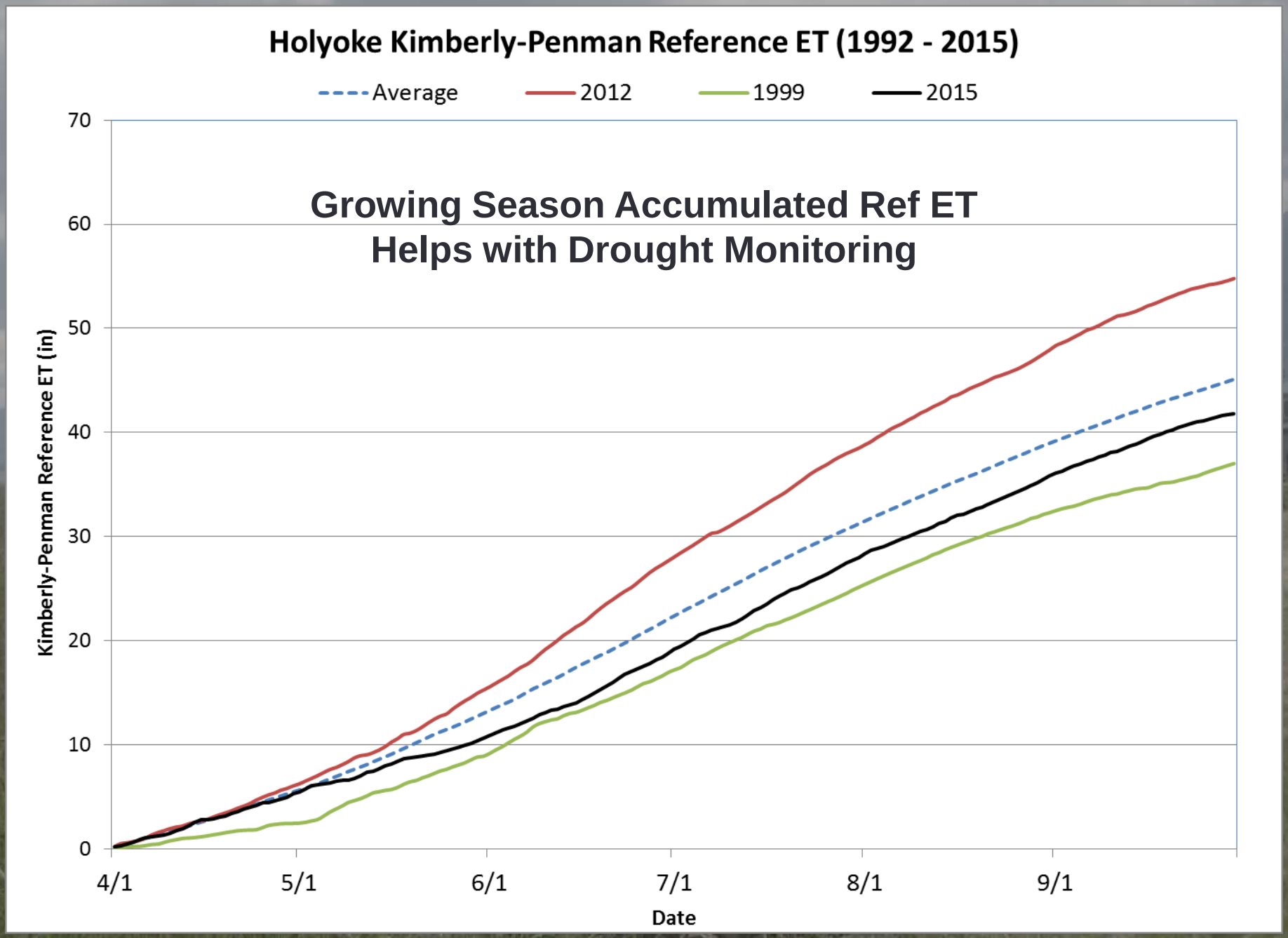
Wind Rose


Day Time (7am–6pm) Wind Rose for Delta
20%
16%
12%
8%
4%
N
mph
0–1
1–2
2–3
3–5
5–8
8–10
10–13
13–15
15+

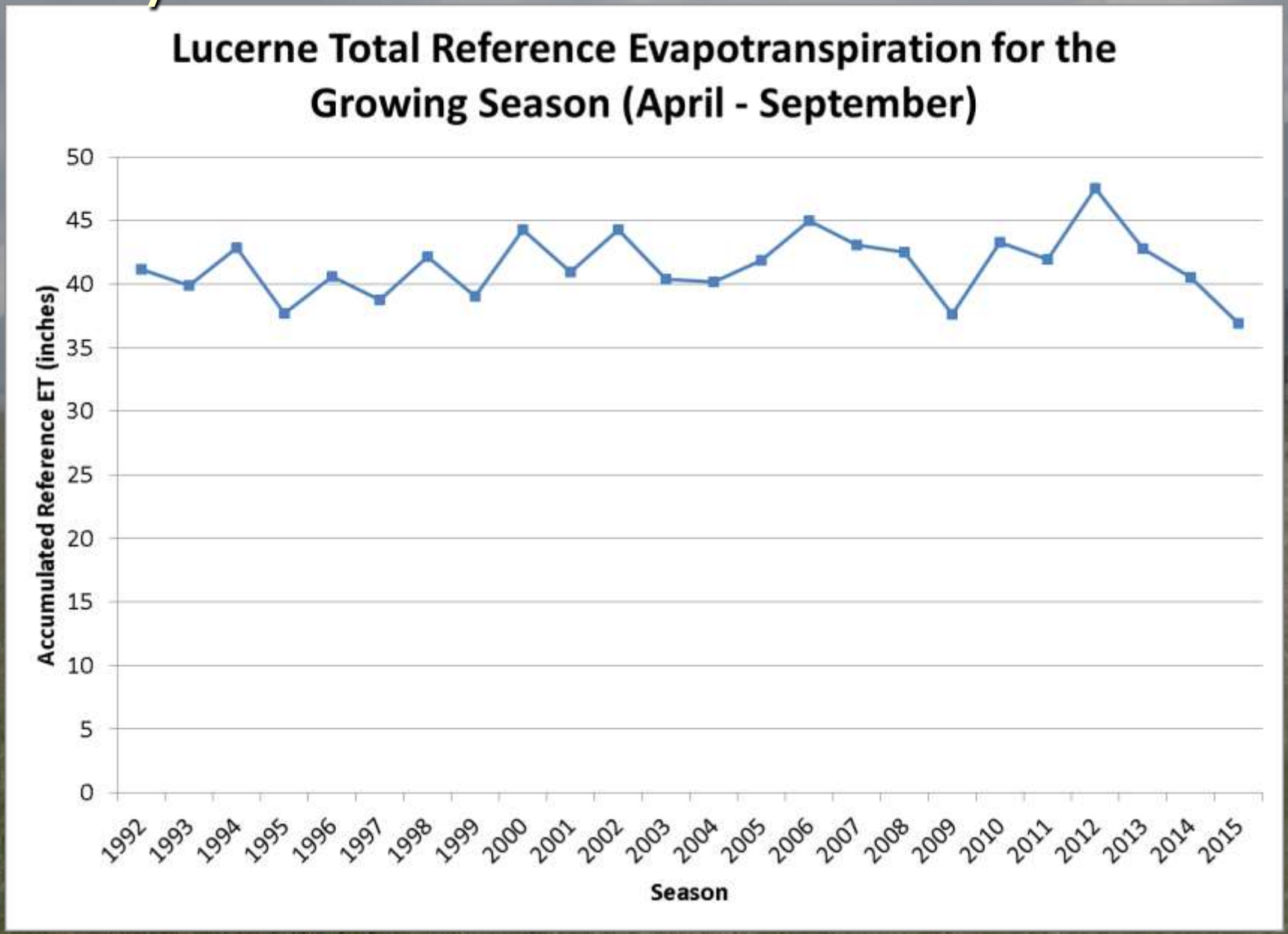

Daily Growing Season (Apr-Sept) Kimberly-Penman Reference ET (in)
OTH01 (partially irrigated)
DLT01 (dryland)
Daily RefET (in)
0.6
0.5
0.4
0.3
0.2
0.1
0
2/26/2011
4/17/2011
6/6/2011
Date
7/26/2011
9/14/2011
11/3/2011

ET data used for drought monitoring and early warning




Holyoke Kimberly-Penman Reference ET (1992 - 2015)
Average
2012
1999
2015
Growing Season Accumulated Ref ET
Helps with Drought Monitoring
Kimberly-Penman Reference ET (in)
70
60
50
40
30
20
10
0
4/1
5/1
6/1
7/1
8/1
9/1
Date

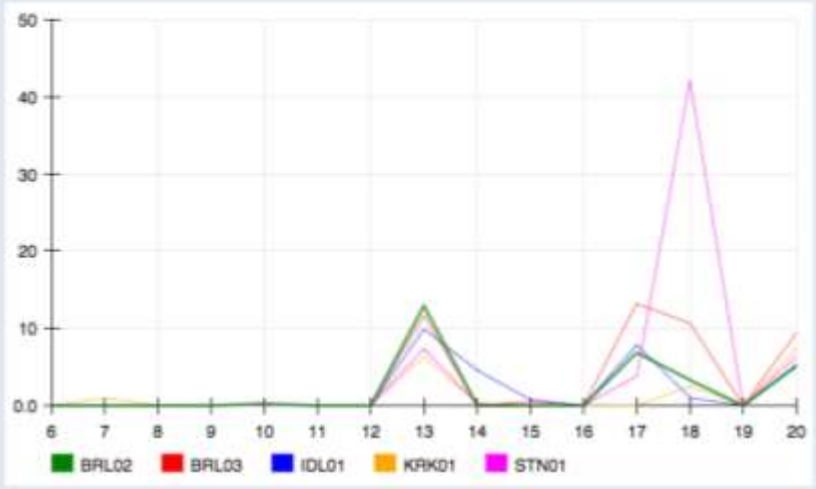
25 years of Ref ET Data now available



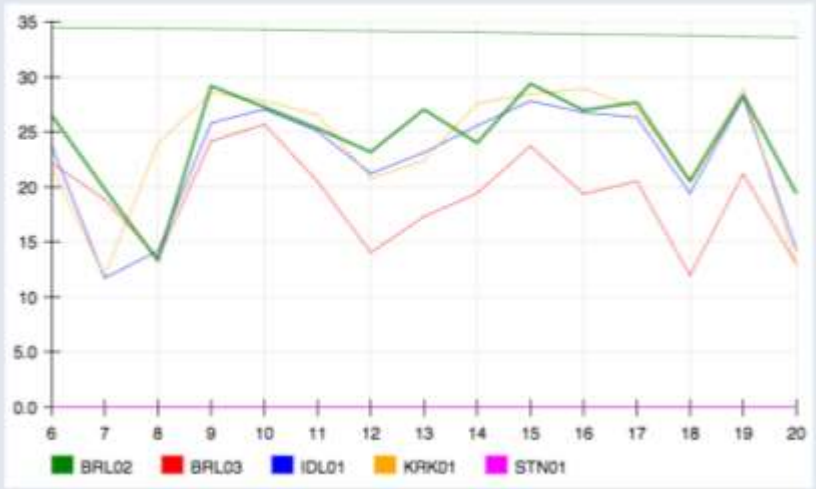
QC A

coagmet.colostate.edu/quality/check/9/daily?beg=2015-07-07&end=2015-07-21

Precipitation (pp) mm



Solar Radiation (sr) kJ m^{-2} min^{-1}

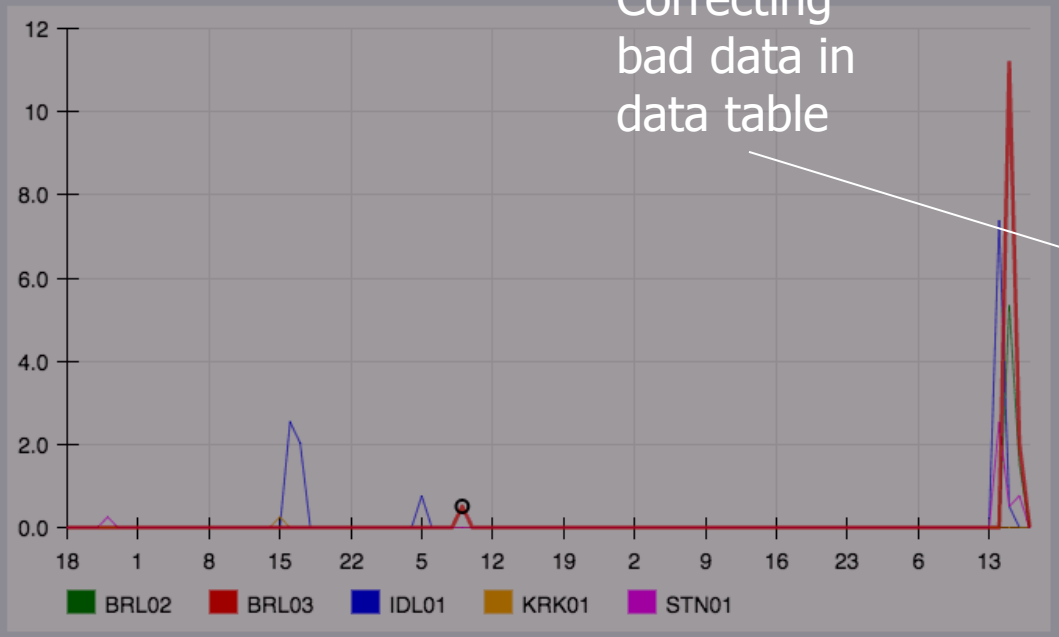


Kansas Drng - South plains

Guest

coagmet.colostate.edu/quality/check/9/hourly?beg=2015-07-15&end=2015-07-18

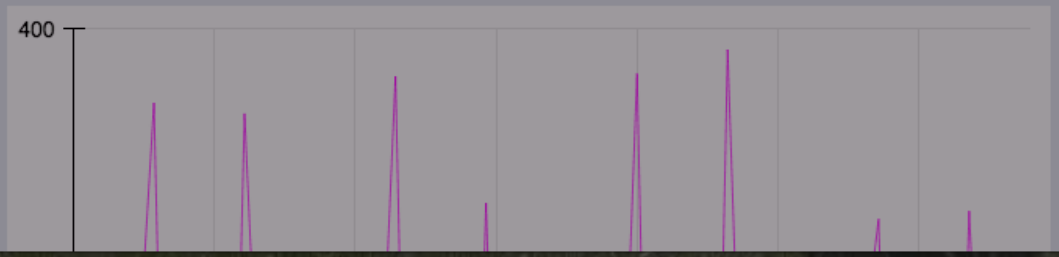
Precipitation (pp) mm



Correcting bad data in data table

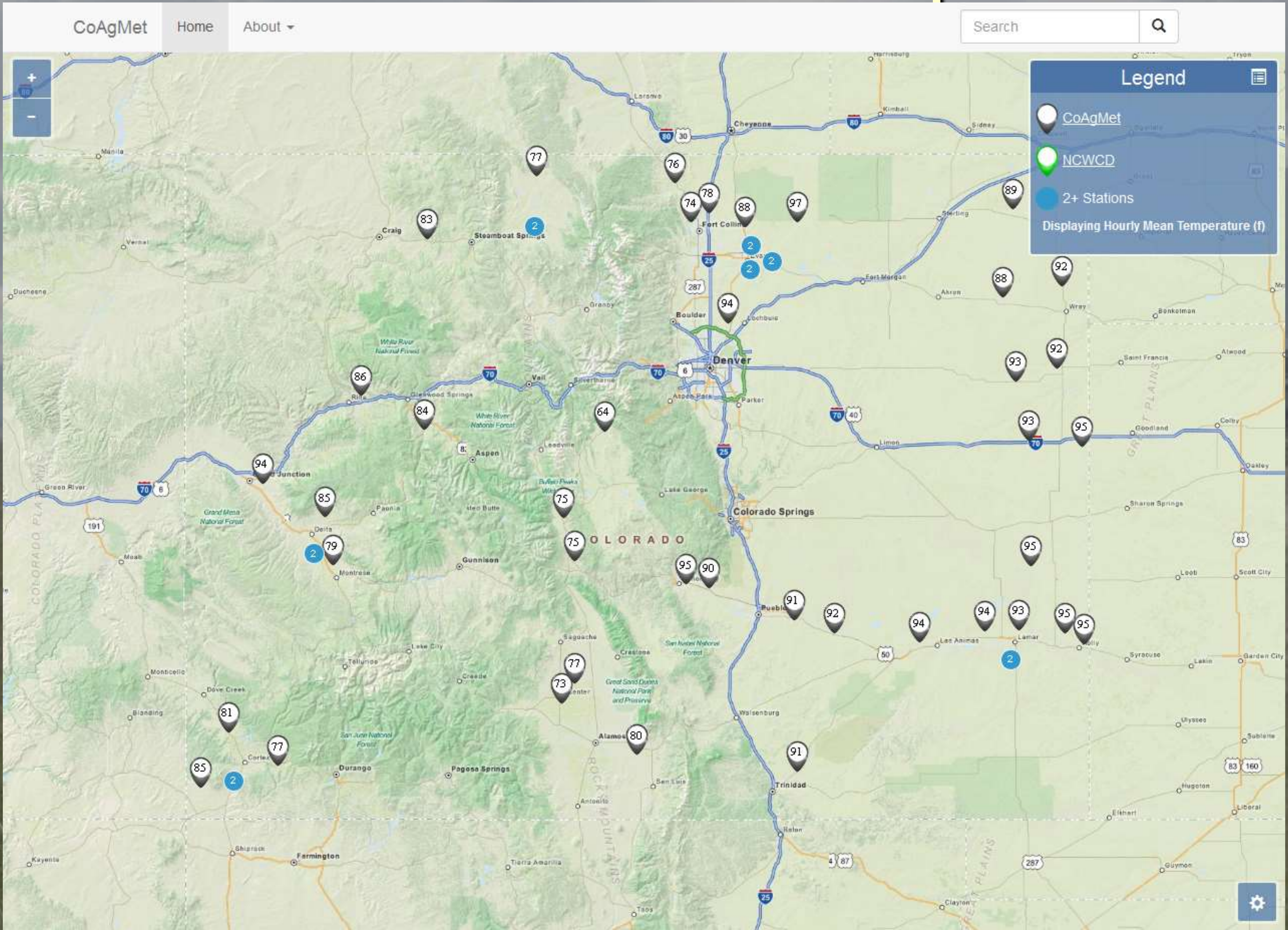
07-16 10	0	0	0	
07-16 11	0	0	0.762	
07-16 12	0	0	0	
07-16 13	0	0	0	
07-16 14	0	0	0	
07-16 15	0.508	0	0	
07-	0.0	0	0	
07-16 17	0	0	0	
07-16 18	0	0	0	
07-16 19	0	0	0	
07-16 20	0	0	0	
07-16 21	0	0	0	
07-16 22	0	0	0	
07-16 23	0	0	0	
07-17 00	0	0	0	

Solar Radiation (sr) kJ m^{-2} min^{-1}

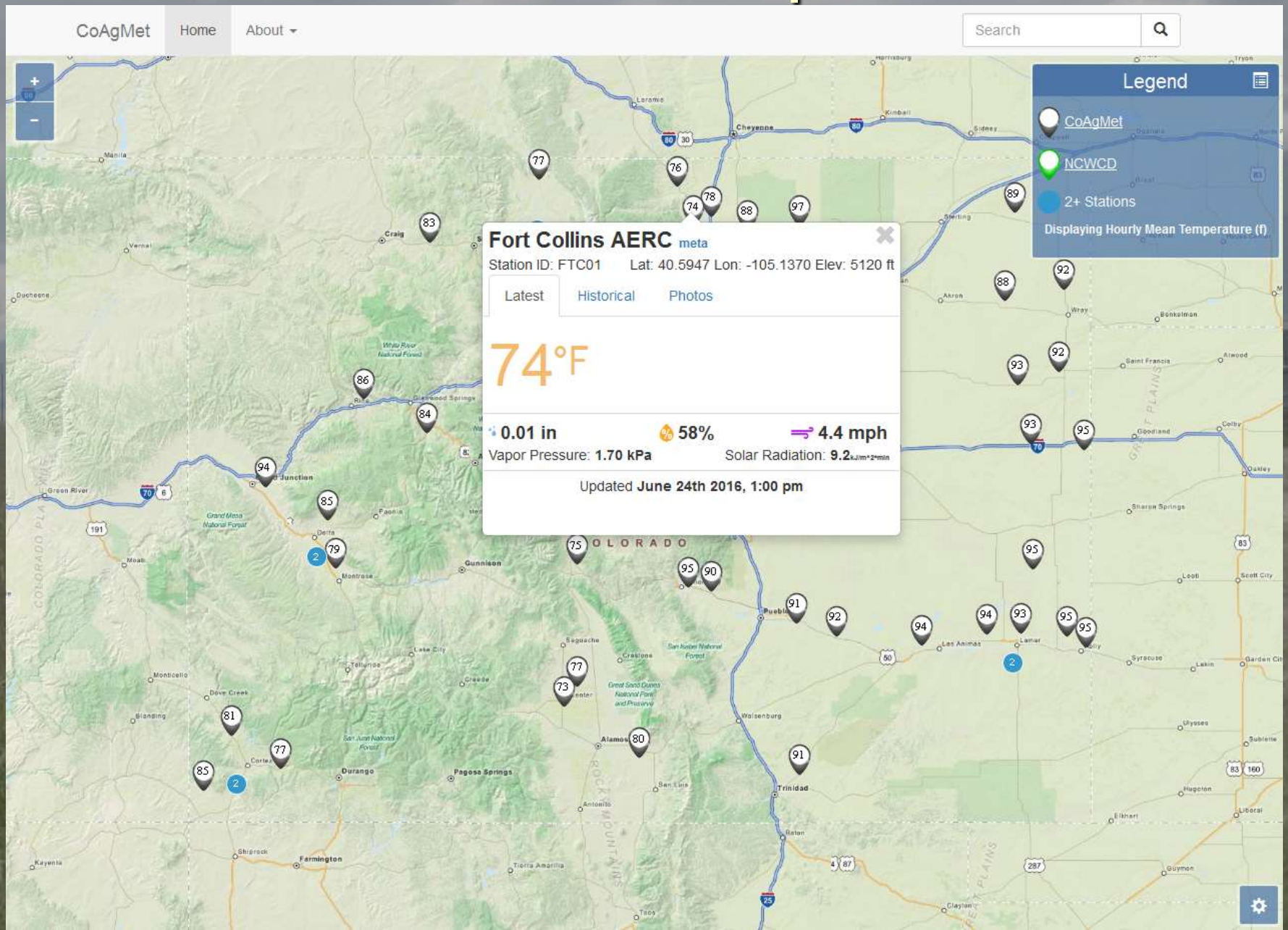


Time	BRL02	Rso	BRL03	Rso
07-15 00	0.041	0.000	0	0.000
07-15 01	0.041	0.000	0	0.000
07-15 02	0.041	0.000	0	0.000
07-15 03	0.041	0.000	0	0.000
07-15 04	0.041	0.000	0	0.000

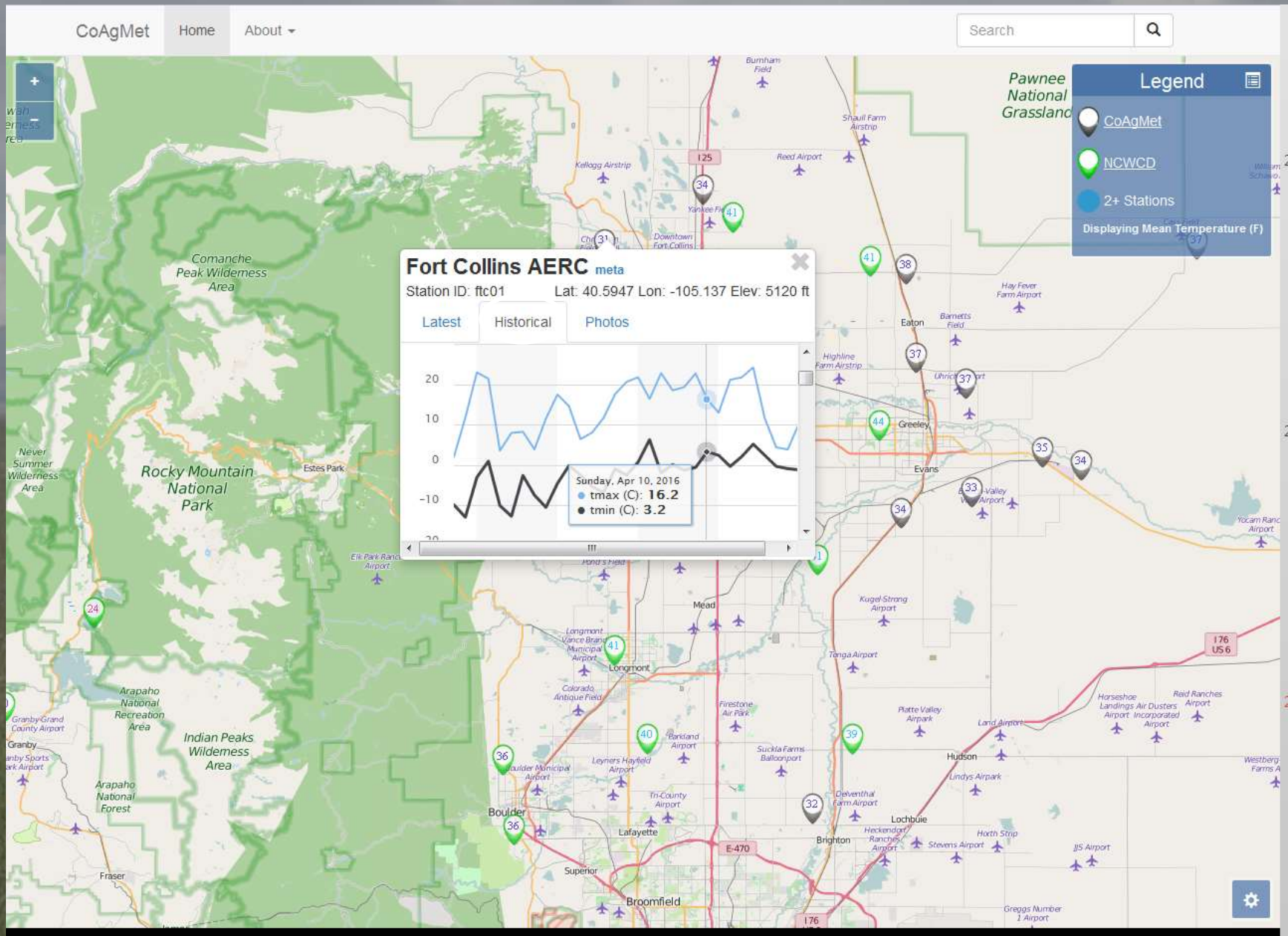
An interactive map



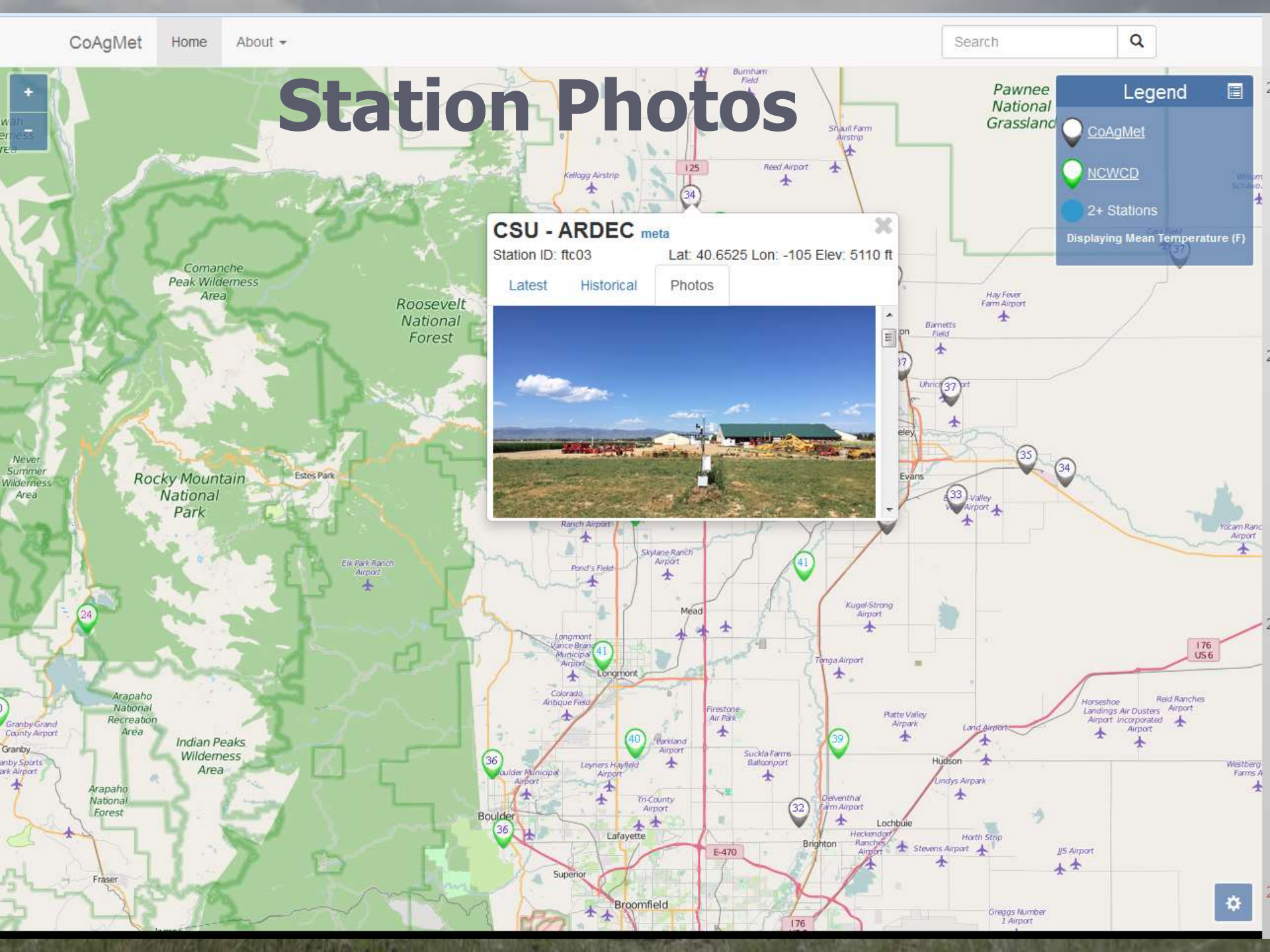
Most recent data for specific station



Can view historical data



Station Photos



All 4 directions plus the ground, and past photos

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July 17th 2015

Facing north on July 17th, 2015

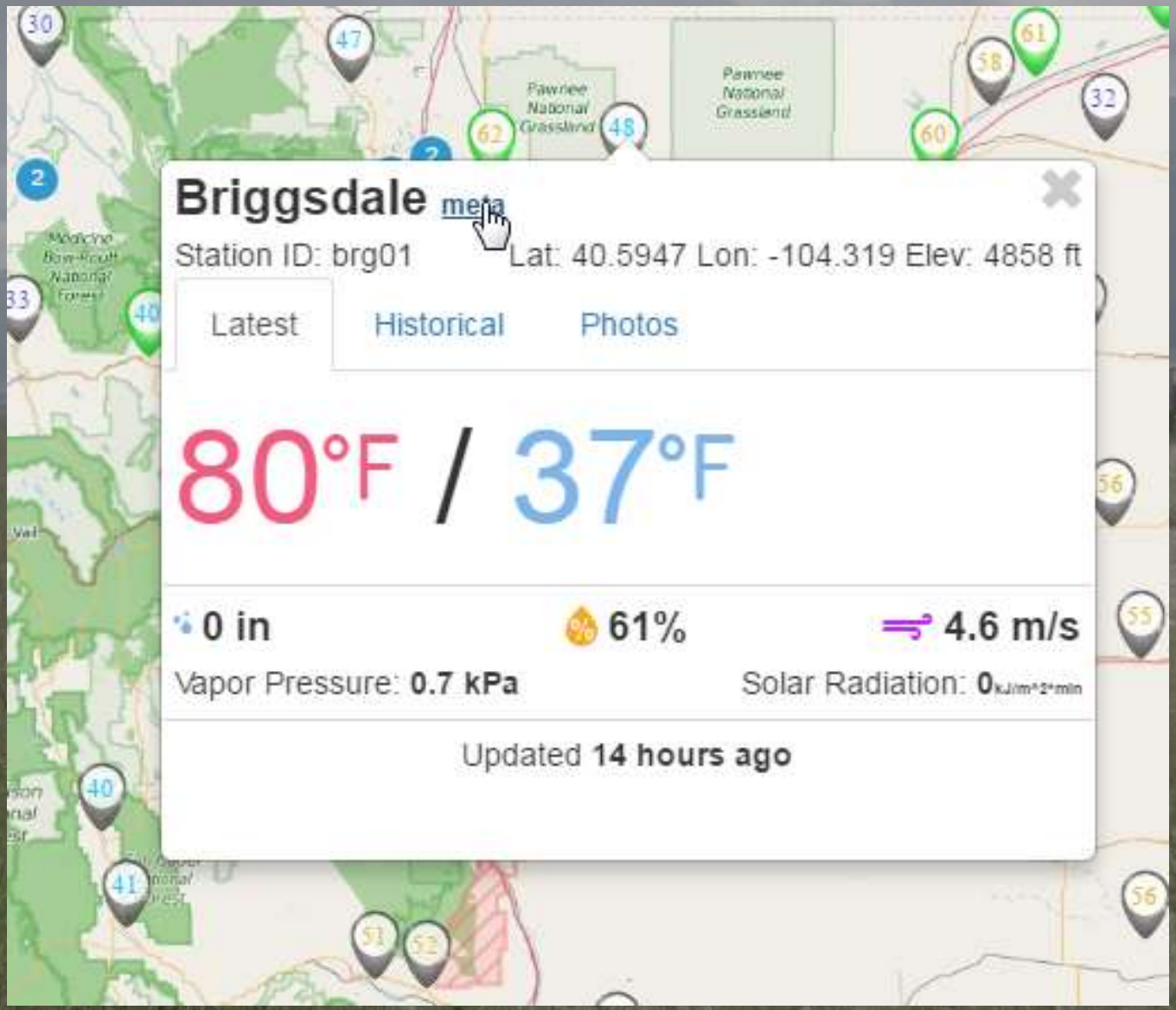
Facing west on July 17th, 2015

Facing east on July 17th, 2015

Facing south on July 17th, 2015

Facing down on July 17th, 2015

Station metadata



2016-04-07

Station Information

Time Service Started
12:45:00

Reason For Visit
Routine Maintenance

Serviced By

Phone Type

Modem

Mdn

Msn

Modem Esn Hex

Modem Esn Dec

Modem Ip

Battery Setup

Antenna

Data Logger

Wiring Panel

Power Supply

Solar Panel

Phone Bill Payer

Name On Phone Bill

Sensors

	Temp/RH Sensor	Pyranometer
Model		
SN		
Installed		

Previous Serial Numbers and Removal Dates

Service Work

Anemometer Bearings

Wind Vane Bearings

Wind Vane Direction

Wind Sentry Level

Temp Rh

Pyranometer

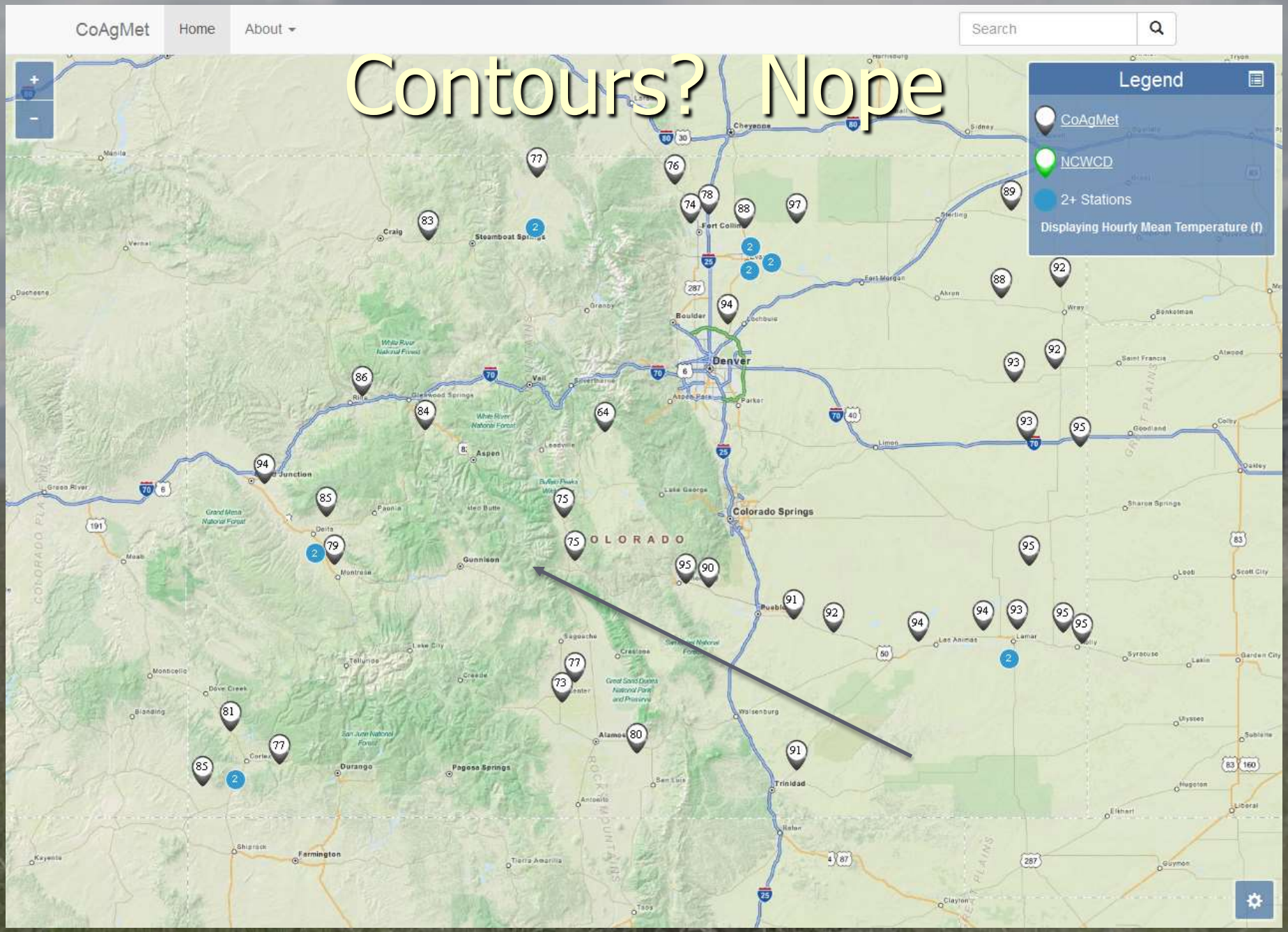
Pyranometer Clean

Pyranometer Level

Rain Gage Test

Rain Gage Clean

Rain Gage Level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