Update on Arkansas Valley Lysimeter Operations

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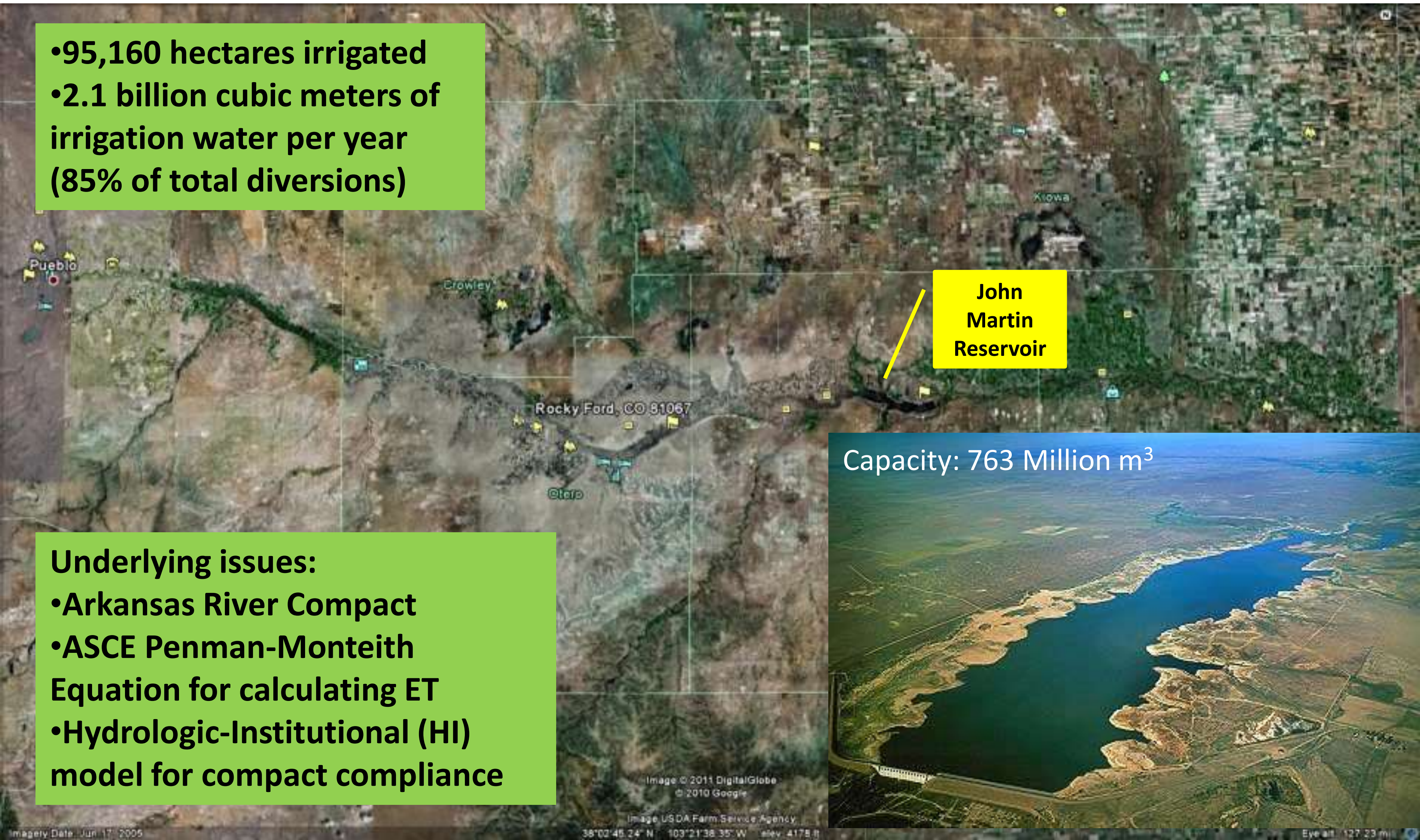
DEPARTMENT OF NATURAL RESOURCES

A reliable method of estimating crop consumptive water use (ET) is needed for the Lower Arkansas Valley of Colorado.

- 95,160 hectares irrigated
- 2.1 billion cubic meters of irrigation water per year (85% of total diversions)



Underlying issues:
- Arkansas River Compact
- ASCE Penman-Monteith Equation for calculating ET
- Hydrologic-Institutional (HI) model for compact compliance

Estimation of crop evapotranspiration (ET_c)

$$ET_c = ET_{rs} \times K_{cr}$$

where

ET_{rs} = reference crop ET (tall reference like alfalfa)

= the ET rate from a uniform surface of dense, actively growing vegetation (hypothetical crop) having specified height (50 cm or 20 inches for alfalfa) and surface resistance (to vapor transport), not short of soil water, and representing an expanse of at least 100 m (328 ft) of the same or similar vegetation (ASCE-Standardized Reference ET equation)

K_{cr} = crop coefficient based on tall reference

$$= \frac{ET_c}{ET_{rs}}$$

ASCE Penman-Monteith ET equation

Ground heat flux

Net radiation

Air temperature

$$ET_{rs} = \frac{0.408\Delta(R_n - G) + \gamma \dfrac{C_n}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + C_d u_2)}$$

Wind speed

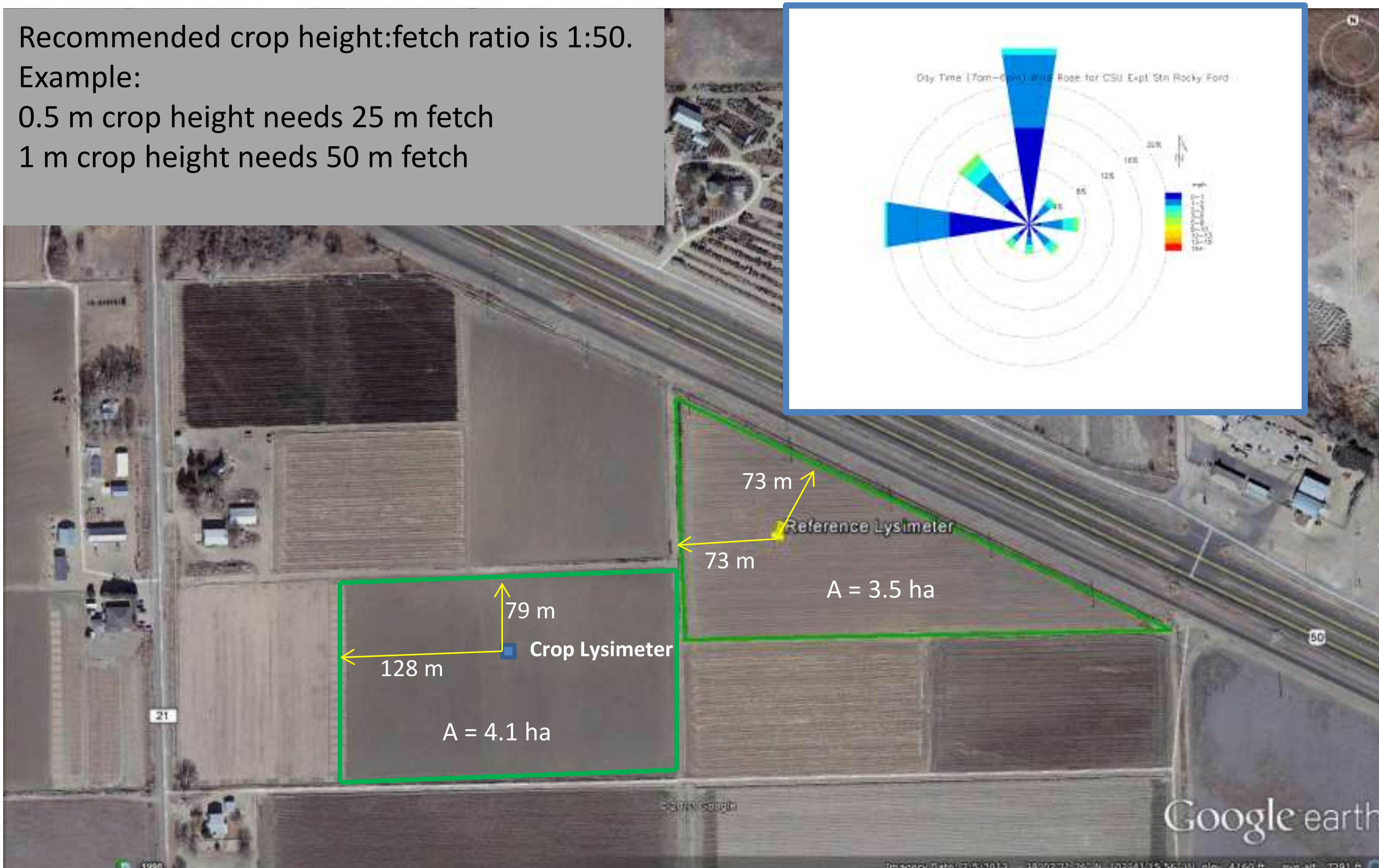
Humidity

Weighing lysimeter

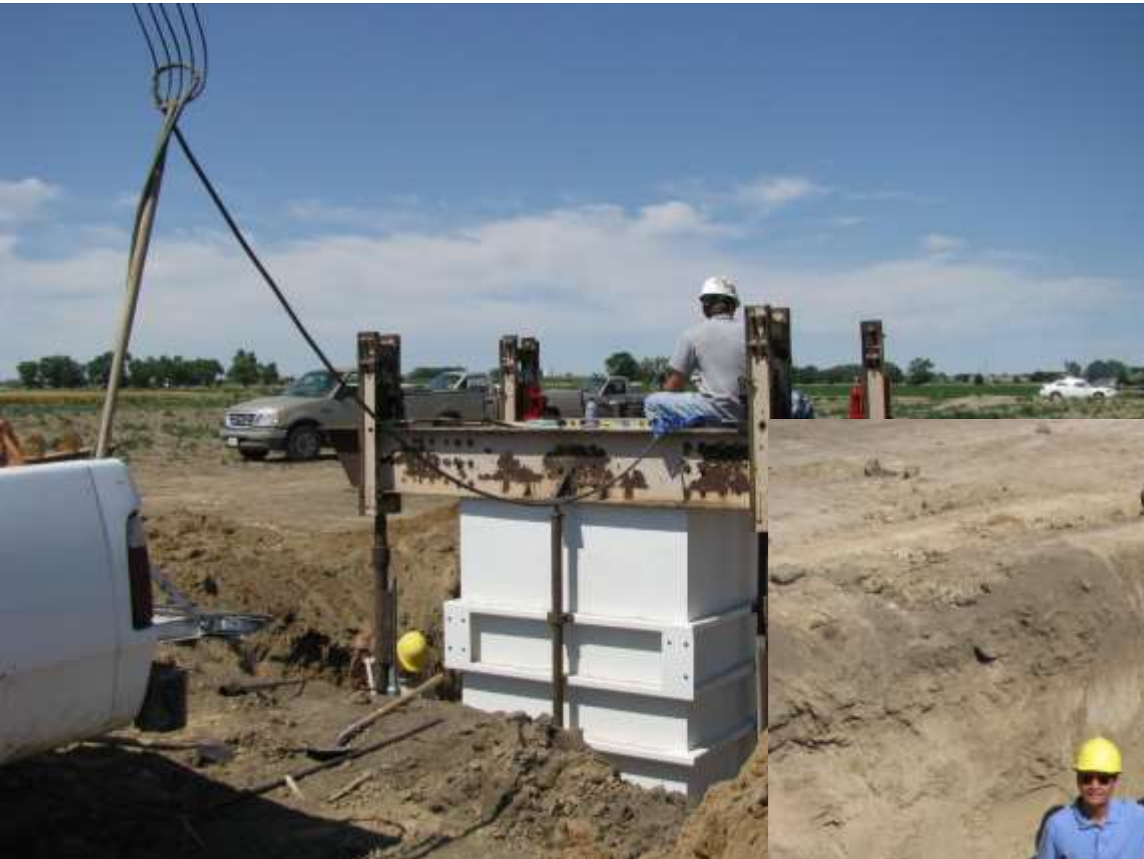
- Measurement of ET_c by water balance can be achieved with a weighing lysimeter.
- Precision weighing lysimeters measure water loss and gain from a control volume of cropped soil by tracking the change in mass of the control volume, with precision of a few hundredths of a millimeter of water.

Lysimeter fields at the AVRC

Recommended crop height:fetch ratio is 1:50.
Example:
0.5 m crop height needs 25 m fetch
1 m crop height needs 50 m fetch

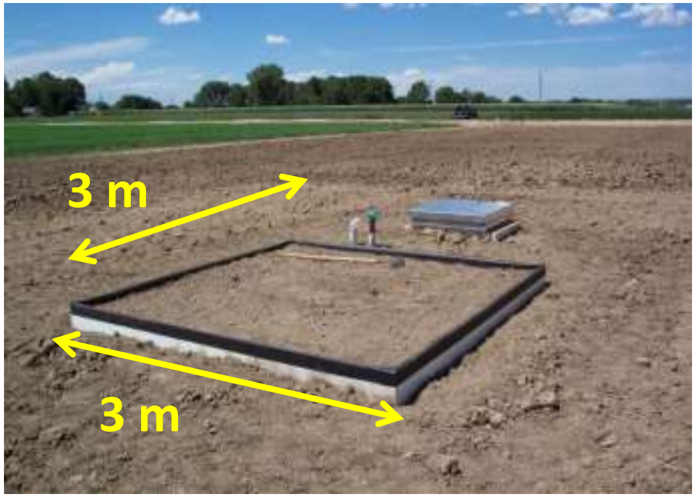


Acquisition of Undisturbed Soil Monolith



Lysimeter installation

Mechanical advantage = 1:100



Load cell resolution

Interface ® SM-50 load cell

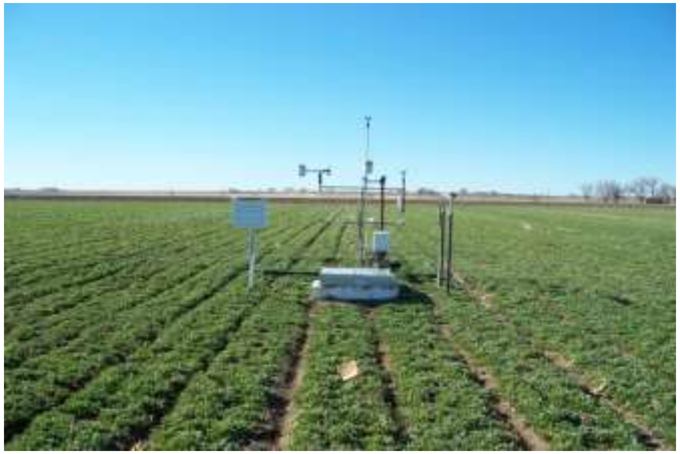
Capacity: 22.7 kg
(2270 kg equivalent range in monolith)
Non-linearity & hysterisis: 0.05%
Resolution: 0.13 mm H_2O

Weighing scale calibration (0.02% std. dev.)

mass (kg) = 685.4 x LC – 142.9; $r^2 = 0.999$

mm H_2O = 74.6 x LC – 15.7; where LC = load cell output (mV/V)

Irrigation and Management



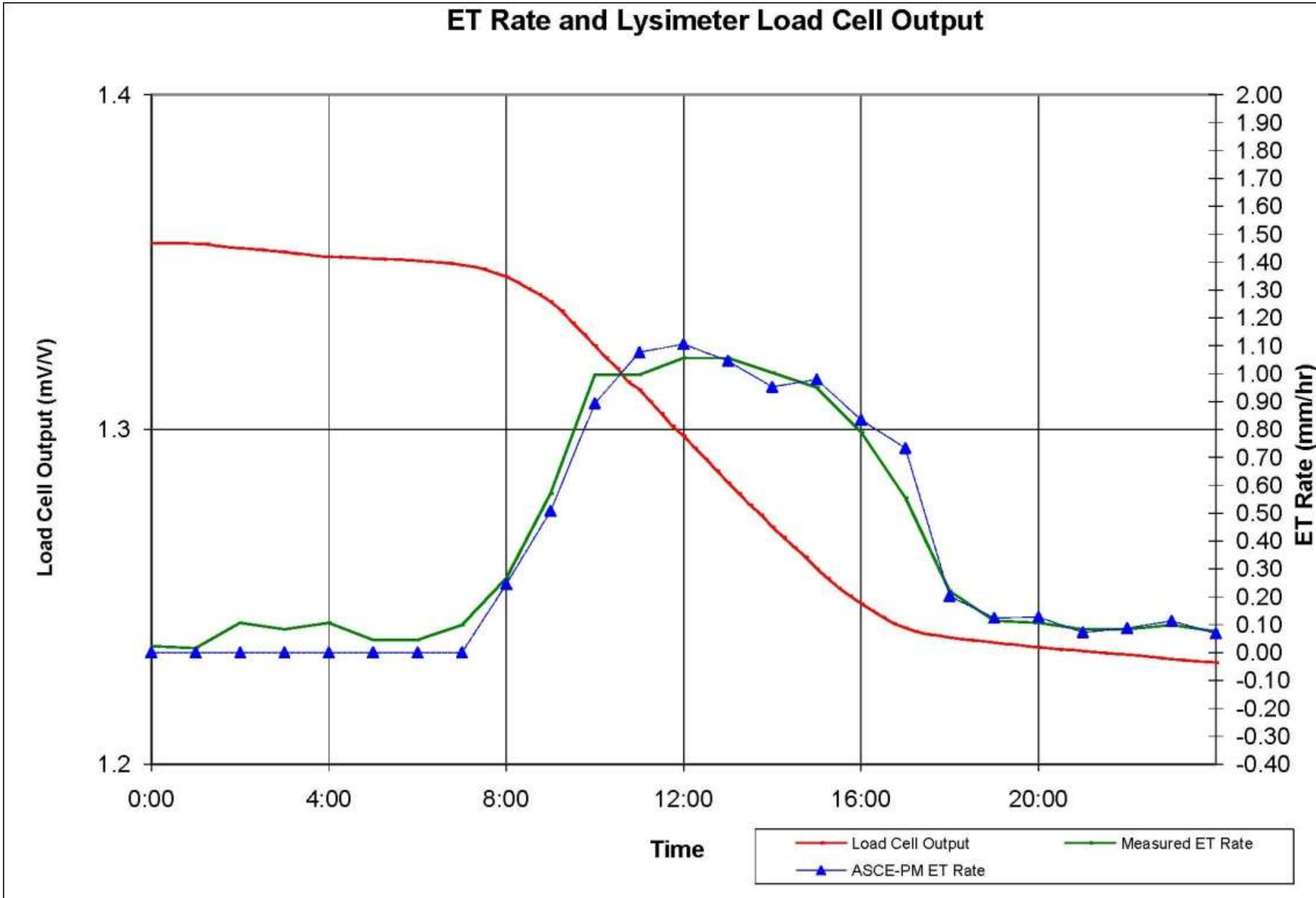
Lysimeter Water Balance

$$ET_c = P + Irr - D + \Delta S$$

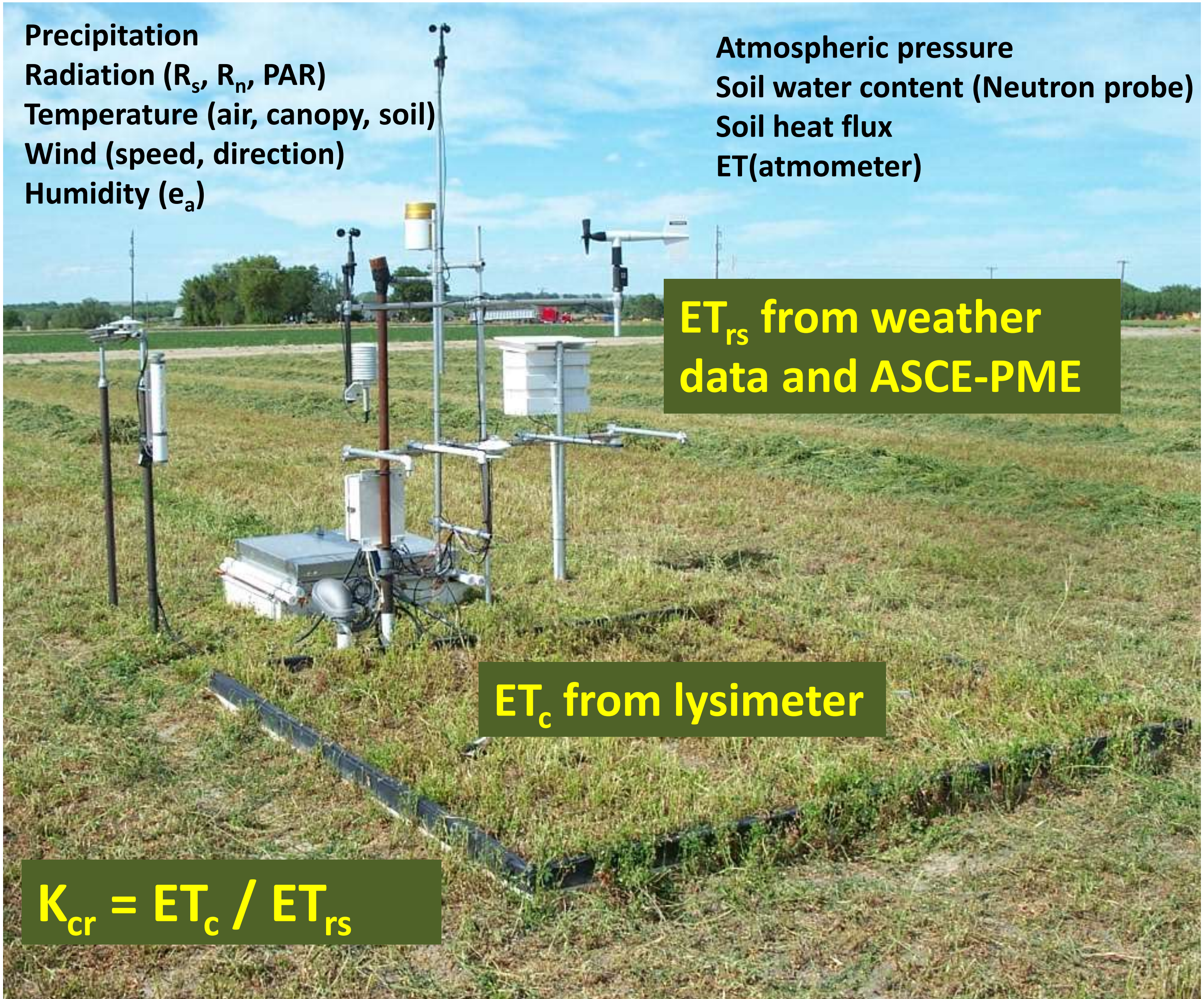
where:

- ET_c = crop evapotranspiration
- P = precipitation
- Irr = irrigation
- D = drainage
- ΔS = change in profile soil water content

Example load cell output, lysimeter ET_c, and ASCE Penman-Monteith ET_r on 9/30/2009



Getting daily crop coefficient (K_c) values

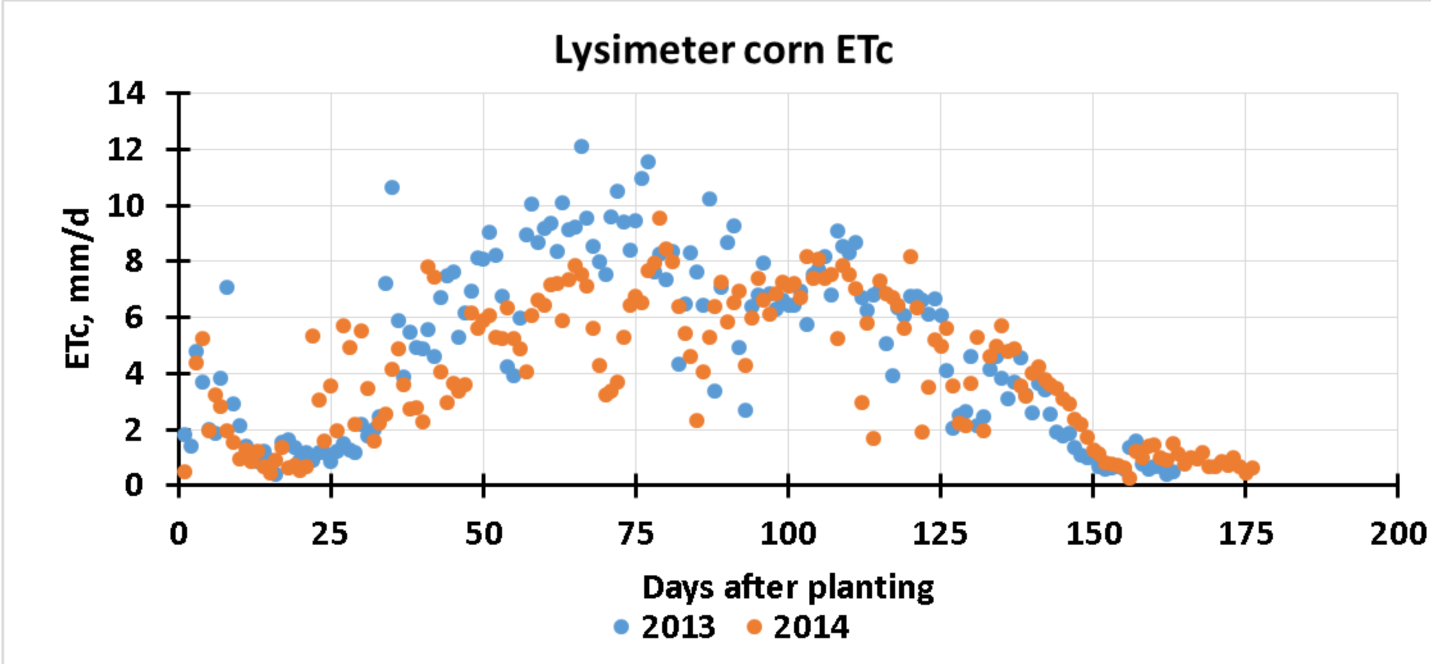


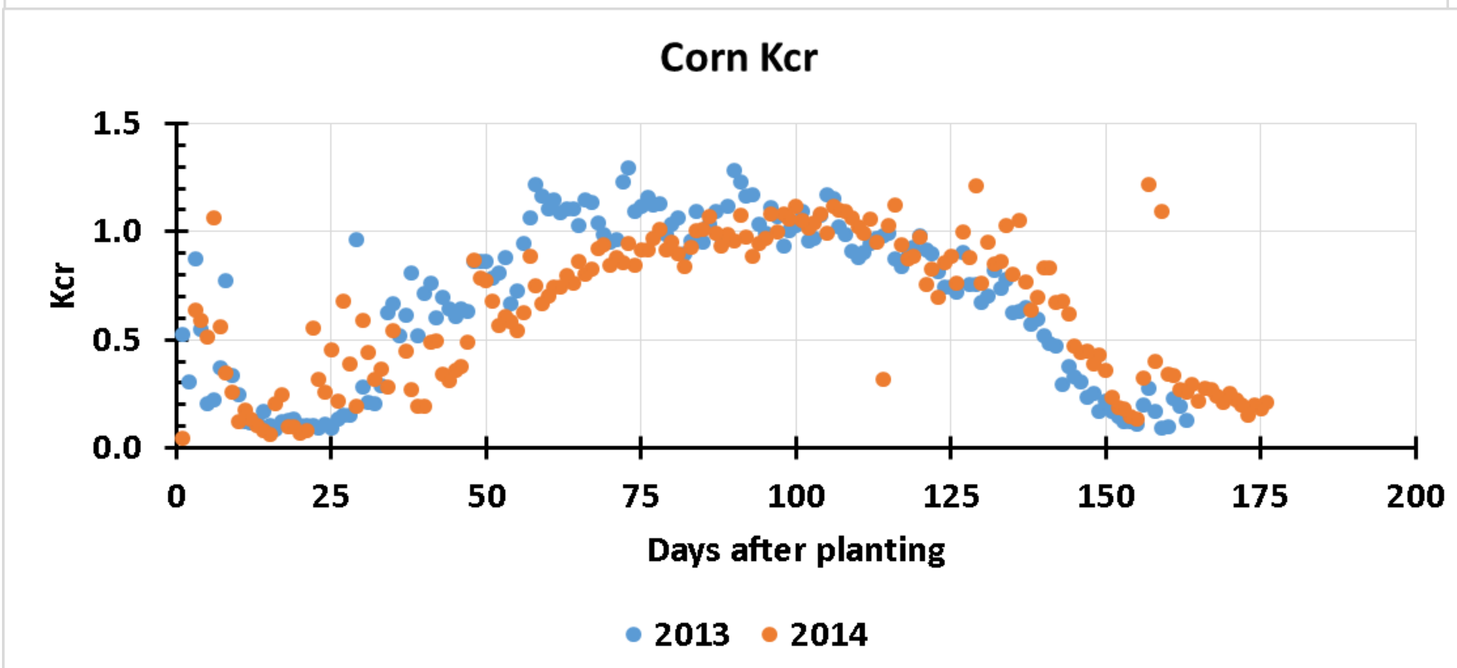
Corn on the large lysimeter (12 June 2013)

Seasonal water balance of the lysimeter

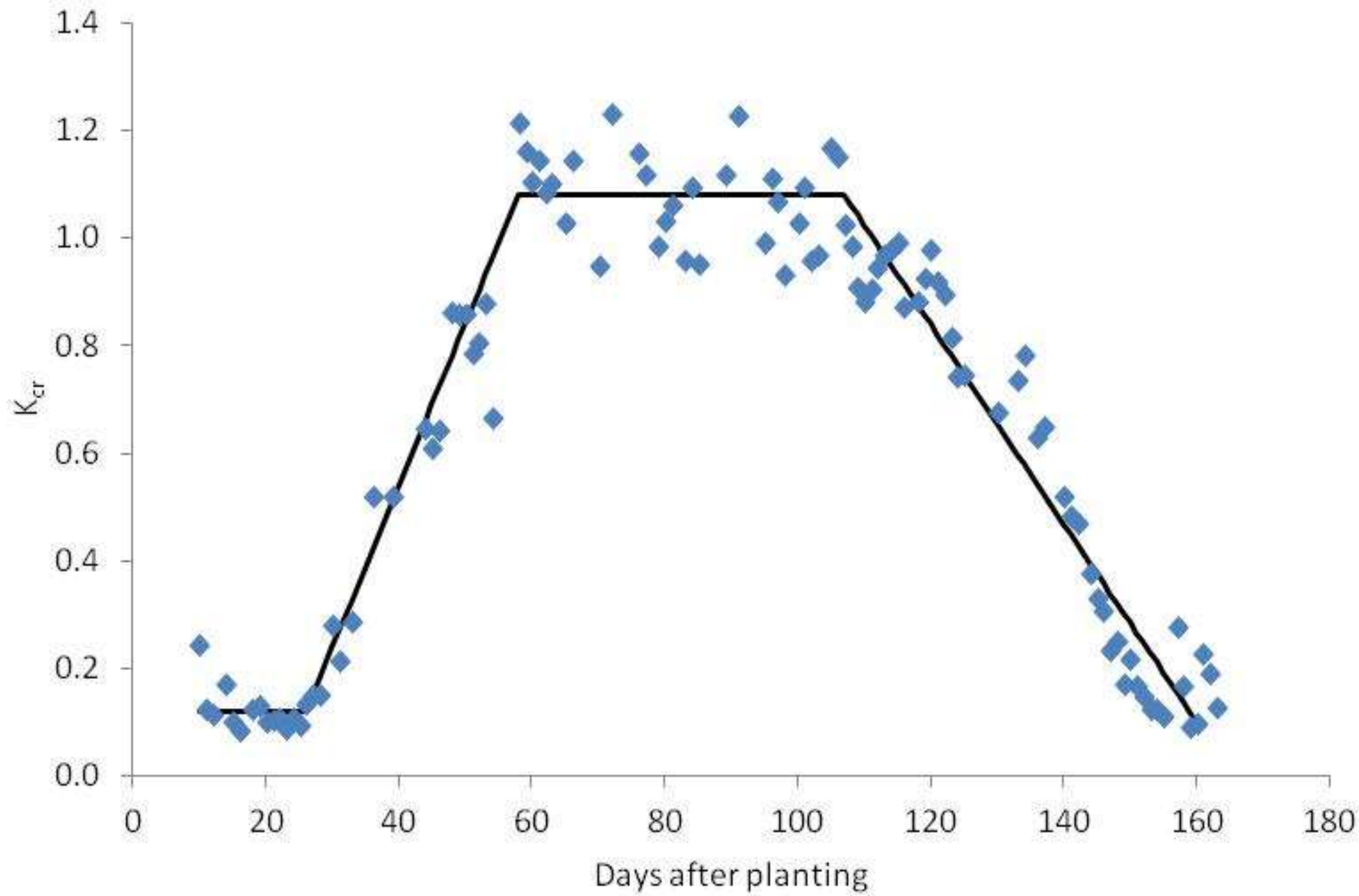
	Corn	Corn	Winter wheat
	5/6/13 – 10/17/13	5/6/14 – 10/30/14	10/2/15 – 7/12/16
No. of days:	165	178	285
Component	Depth of water, mm	Depth of water, mm	Depth of water, mm
ET_c	817.68	726.34	792.90
Irr	1009.89	624.69	685.38
P	117.52	313.22	312.18
DP	324.40	218.18	81.86
ΔS	-18.31	-3.61	56.33

Abbreviations: ET_c = crop evapotranspiration, Irr = irrigation, P = precipitation, DP = deep percolation, ΔS = change in soil water content


Lysimeter corn ETc
ETc, mm/d
14
12
10
8
6
4
2
0
0
25
50
75
100
125
150
175
200
Days after planting
2013
2014

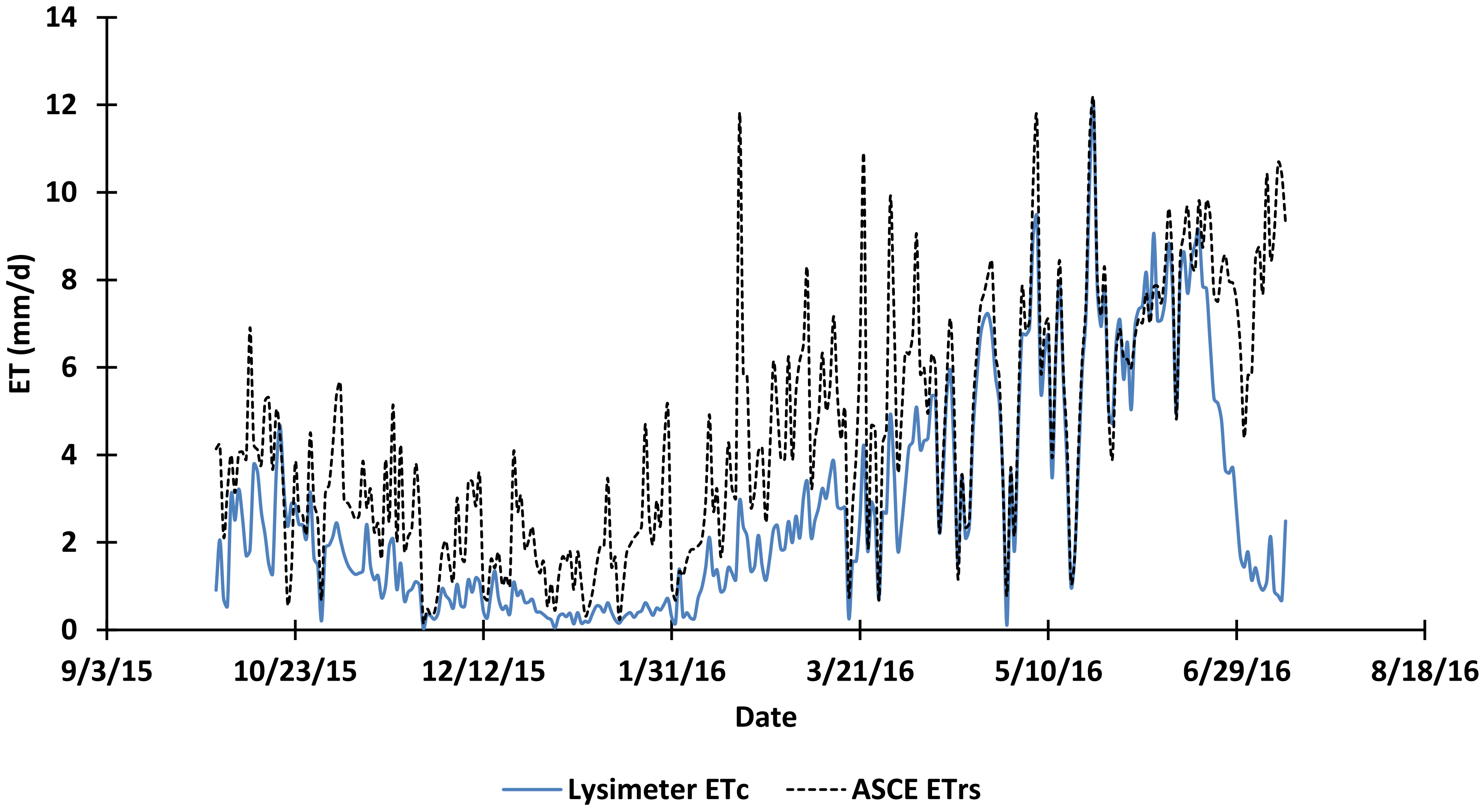

Corn Kcr
Kcr
1.5
1.0
0.5
0.0
0
25
50
75
100
125
150
175
200
Days after planting
2013
2014

Seasonal corn crop coefficient (K_{cr}) curve for 2013 at Rocky Ford, CO

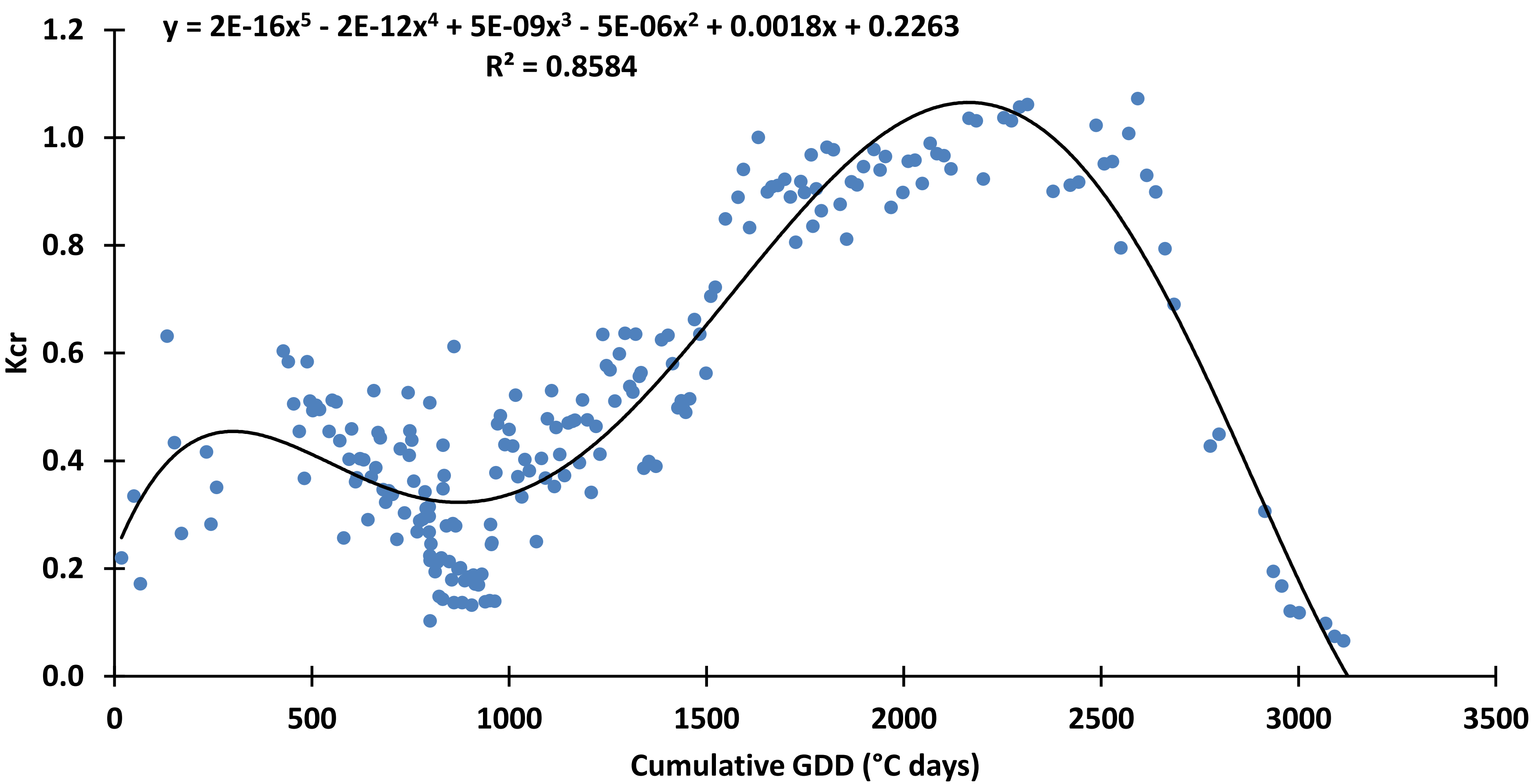


Winter wheat on the small lysimeter (2015-2016)

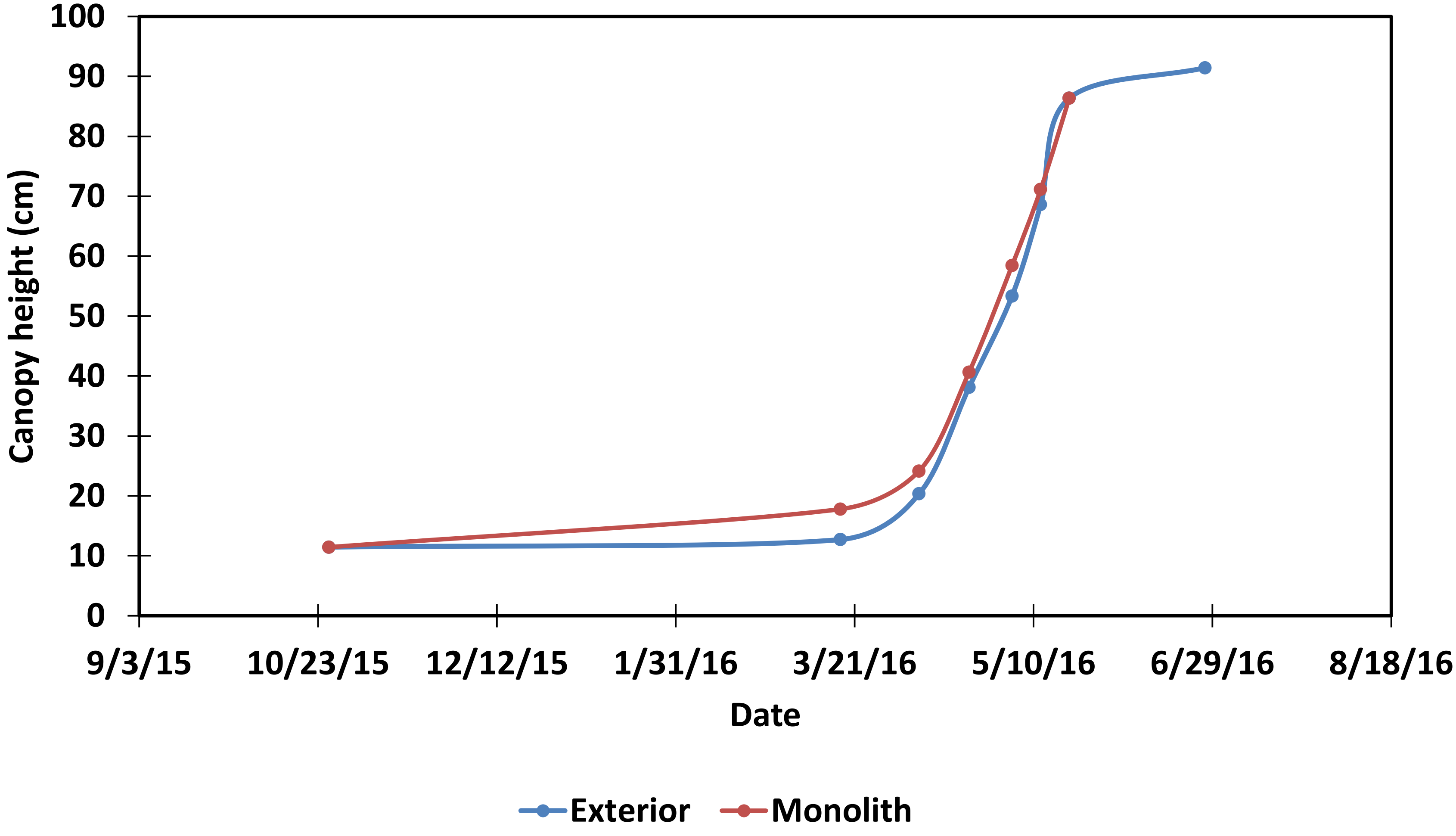
Daily winter wheat ET_c and ASCE standardized Penman-Monteith ET_{rs} (10/2/2015 – 7/12/2016)



Average winter wheat crop coefficient (K_{cr}) curve for 2015-2016 at Rocky Ford, CO.



Wheat canopy height



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The Water Irrigation Scheduler for Efficient Application (WISE) online tool for Colorado

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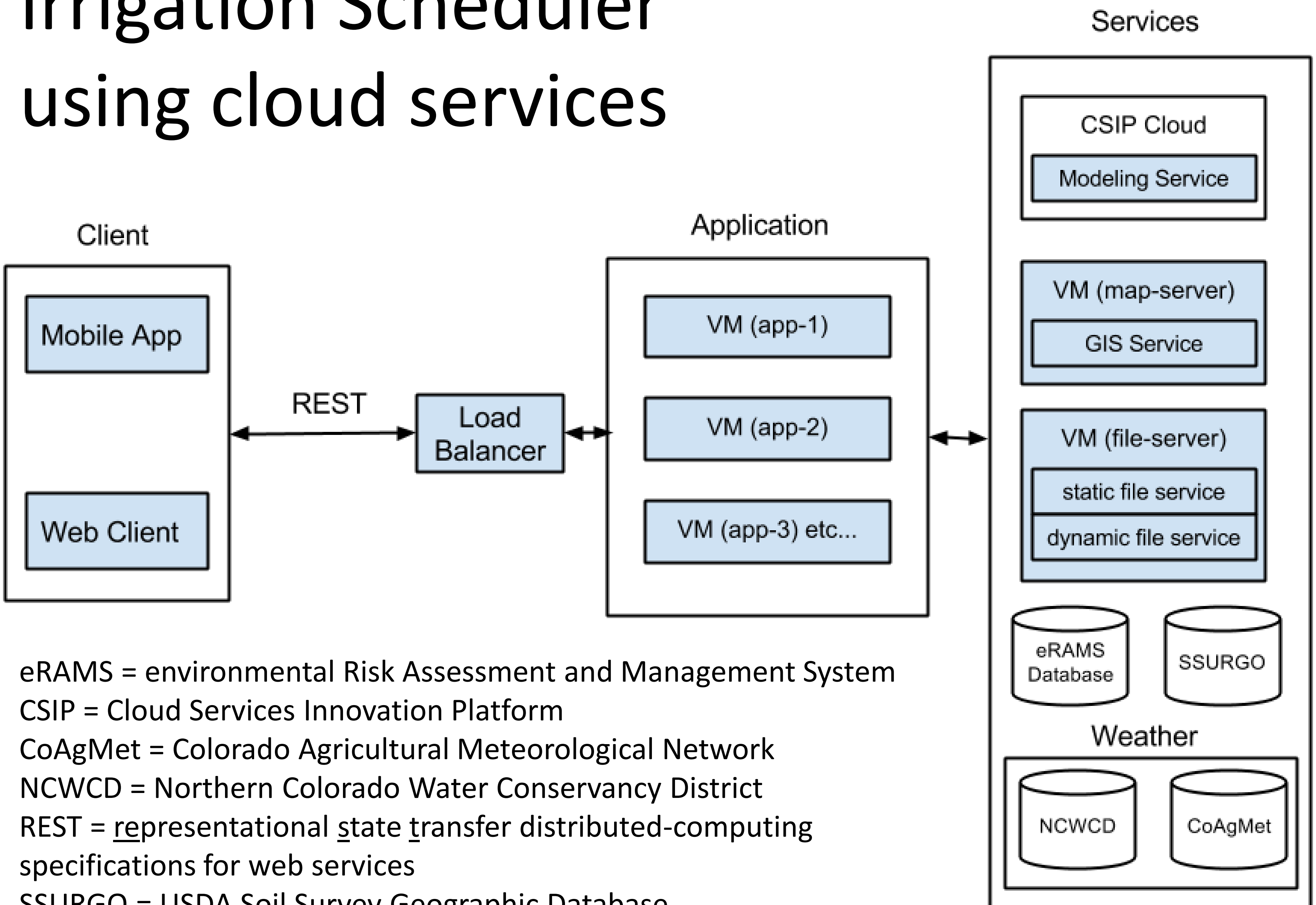
National Institute of Food and Agriculture

Irrigation Scheduler using cloud services

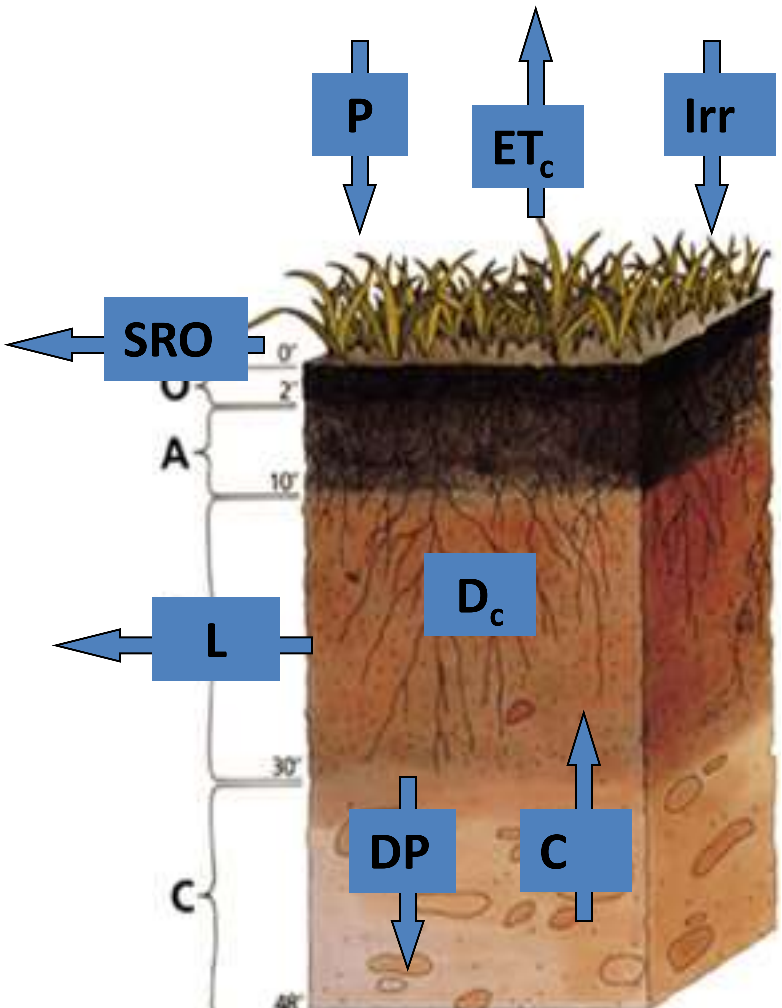


eRAMS = environmental Risk Assessment and Management System
CSIP = Cloud Services Innovation Platform
CoAgMet = Colorado Agricultural Meteorological Network
NCWCD = Northern Colorado Water Conservancy District
REST = <u>re</u>presentational <u>s</u>tate <u>t</u>ransfer distributed-computing specifications for web services
SSURGO = USDA Soil Survey Geographic Database
VM = virtual machine

Daily Water Balance of the Soil Profile:

$$D_c = D_p + ET_c - P - Irr + SRO$$

(if $D_c < 0$, then $D_c = 0$)



P = precipitation

Irr = irrigation

ET_c = crop evapotranspiration

SRO = surface runoff

D_c = current deficit (net Irr req't.)

D_p = previous deficit

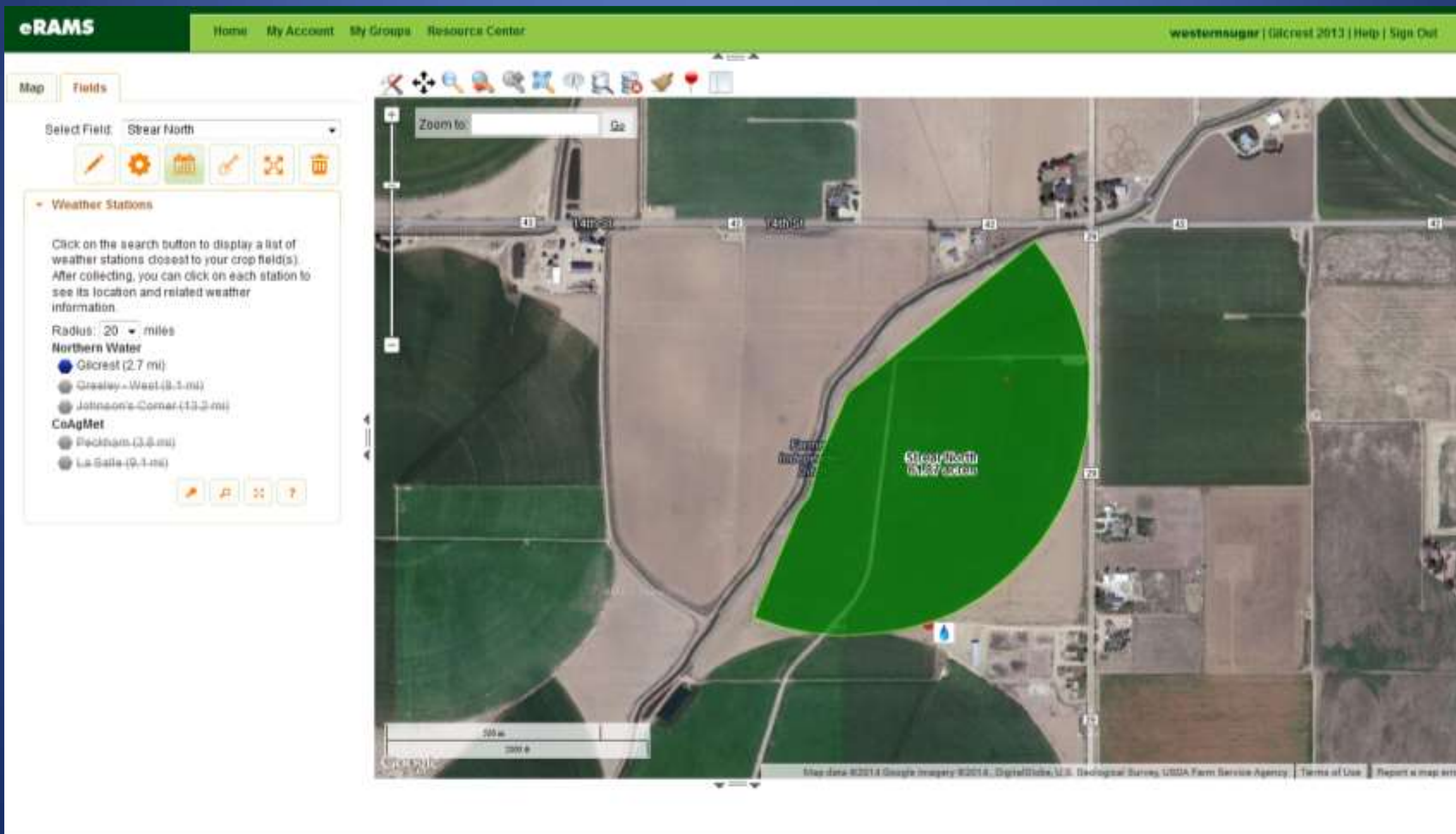
DP = deep percolation; if $D_c < 0$

C = capillary rise (assumed 0)

L = lateral flow (0 net)

Source:
http://soils.usda.gov/education/resources/k_12/lessons/profile/

ater rrigation cheduling for WISE fficient Application



Irrigation Schedule - Graph

Comparison of WISE and measured deficits during the 2010-2012 corn growing seasons (Greeley, CO)

Site – Year	n[a]	RMSE[b] (mm)	MBE[c] (mm)	MAE[d] (mm)	RE[e] (%)
North 2010	16	13.0	-0.3	10.6	1.8
South 2010	16	16.4	-1.5	13.1	8.6
North 2011	16	12.1	-1.8	10.8	11.3
South 2011	16	15.7	-1.6	12.6	11.3
North 2012	15	22.9	-12.9	18.0	30.9
South 2012	15	13.4	-2.9	10.8	6.5
All	94	15.9	-3.4	12.6	13.6

[a]n = number of measurements; [b]RMSE = root mean square error; [c]MBE = mean bias error;
[d]MAE = mean absolute error; [e]RE = relative error.

Calculated water balance components using actual and WISE-recommended irrigations for center pivot irrigated corn at Greeley, CO in 2011 (13 June – 10 October).

Water balance component	With actual irrigations (mm)	With recommended irrigations (mm)
ET_c (mm)	**501**	**501**
Gross Irr (mm)	**511**	**372**
P (mm)	**125**	**125**
DP + SRO (mm)	**146**	**37**
ΔS (mm)	**12**	**42**

ΔS = change in soil water storage in managed root zone (1050 mm)

Scheduling using WISE:

- 27% savings in gross irrigation
- 75% reduction in deep percolation (DP) and surface runoff (SRO)

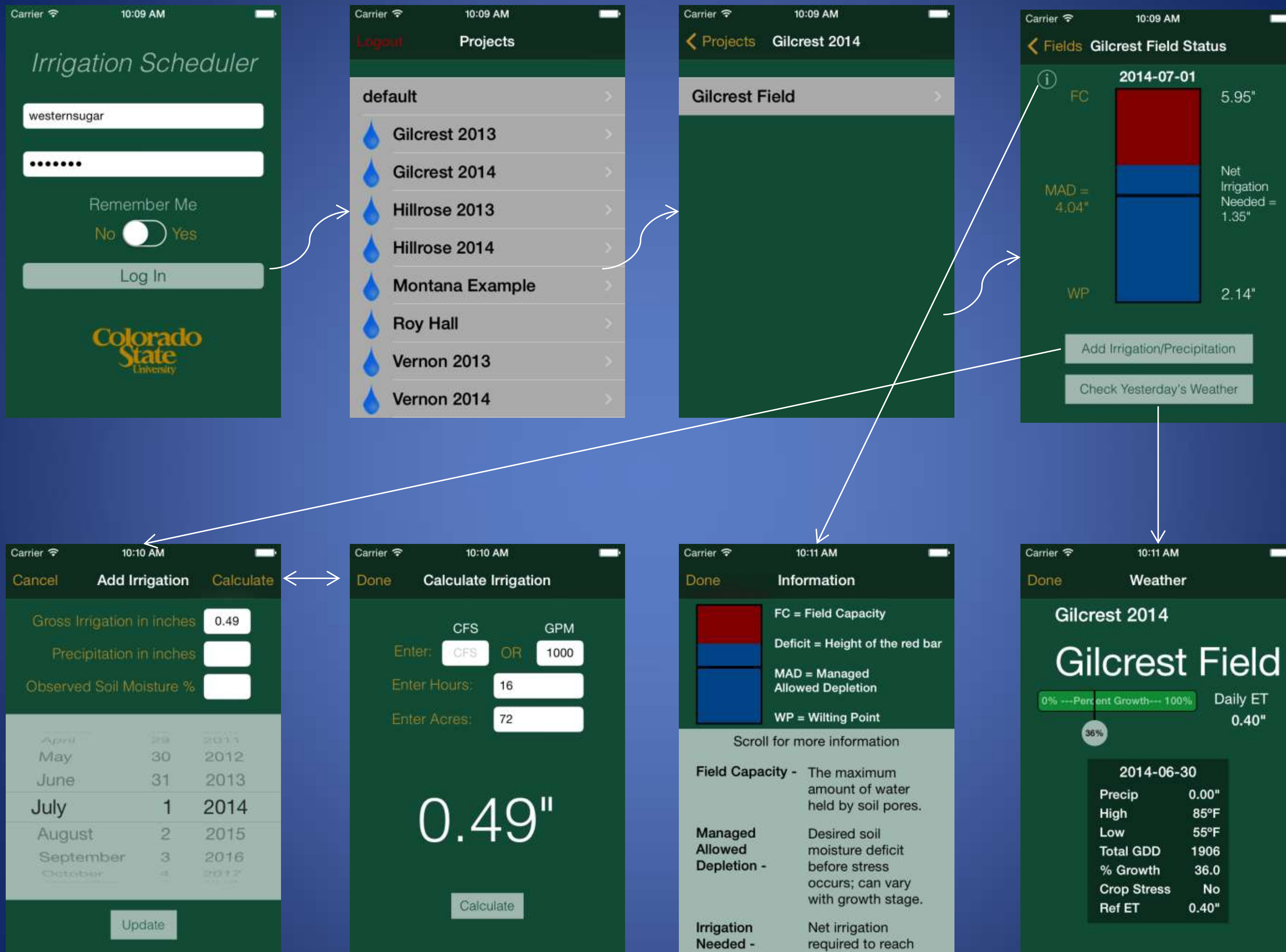
WISE Smart phone Apps

Download on the App Store

https://itunes.apple.com/app/id928128681

android

https://play.google.com/store/apps/details?id=com.erams.wise


Carrier 10:09 AM
Irrigation Scheduler
westernsugar
Remember Me
No Yes
Log In
Colorado State University
Carrier 10:09 AM
Logout Projects
default
Gilcrest 2013
Gilcrest 2014
Hillrose 2013
Hillrose 2014
Montana Example
Roy Hall
Vernon 2013
Vernon 2014
Carrier 10:09 AM
Projects Gilcrest 2014
Gilcrest Field
Carrier 10:09 AM
Fields Gilcrest Field Status
2014-07-01
FC 5.95"
MAD = 4.04"
Net Irrigation Needed = 1.35"
WP 2.14"
Add Irrigation/Precipitation
Check Yesterday's Weather
Carrier 10:10 AM
Cancel Add Irrigation Calculate
Gross Irrigation in inches 0.49
Precipitation in inches
Observed Soil Moisture %
May 30 2012
June 31 2013
July 1 2014
August 2 2015
September 3 2016
Update
Carrier 10:10 AM
Done Calculate Irrigation
CFS GPM
Enter: CFS OR 1000
Enter Hours: 16
Enter Acres: 72
0.49"
Calculate
Carrier 10:11 AM
Done Information
FC = Field Capacity
Deficit = Height of the red bar
MAD = Managed Allowed Depletion
WP = Wilting Point
Scroll for more information
Field Capacity - The maximum amount of water held by soil pores.
Managed Allowed Depletion - Desired soil moisture deficit before stress occurs; can vary with growth stage.
Irrigation Needed - Net irrigation required to reach
Carrier 10:11 AM
Done Weather
Gilcrest 2014
Gilcrest Field
0% ---Percent Growth--- 100%
Daily ET 0.40"
36%
2014-06-30
Precip 0.00"
High 85°F
Low 55°F
Total GDD 1906
% Growth 36.0
Crop Stress No
Ref ET 0.40"

For more information, go to http://wise.colostate.edu/

or see:

Andales, A.A., Bauder, T.A., and Arabi, M. 2014. A Mobile Irrigation Water Management System Using a Collaborative GIS and Weather Station Networks. In: Practical Applications of Agricultural System Models to Optimize the Use of Limited Water (Ahuja, L.R., Ma, L., Lascano, R.; Eds.), Advances in Agricultural Systems Modeling, Volume 5. ASA-CSSA-SSSA, Madison, Wisconsin, pp. 53-84.

Bartlett, A.C., Andales A.A., Arabi, M., Bauder, T.A. 2015. A Smartphone App to Extend Use of a Cloud-based Irrigation Scheduling Tool. Computers and Electronics in Agriculture 111:127-130.

Project Team

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