YUMA CENTER OF EXCELLENCE FOR DESERT AGRICULTURE

FINAL PROJECT REPORT

Granting Agency	Arizona Iceberg Lettuce Research Council		
Project Title & number	**Evapotranspiration from Desert Iceberg Lettuce Production Systems (18-06)**		
Start Date	September 1, 2017	End Date	August 30, 2018
Project Investigator	Paul Brierley Yuma Center of Excellence for Desert Agriculture University of Arizona		
Lead Researcher(s)	Dr. Charles Sanchez Soil, Water, and Environmental Sciences University of Arizona		

Executive Summary

Studies were conducted during the 2017-2018 growing season to measure ET from six field production sites of lettuce. We used Eddy Covariance methodology for measuring ET in all sites. Measured ET ranged from 241 to 310 mm (9 to 12 inches) and seemed to vary by planting season. These data provide reliable ET estimates aligned with current lettuce production practices and will serve as a basis for revised crop coefficients. These data will also be combined with data collected in 2016-2017, and that currently being collected in 2018-2019, and used to calibrate ET models based on space based sensors, which is an objective of our 2018 proposal.

Introduction

Lettuce production in Yuma is a multi-million dollar industry relying entirely on irrigation water from the Colorado River. However, competition for water between nations, states, and agricultural, industrial, urban and environmental interests is already commonplace and all users are being challenged to use water more efficiently.

The total amount of water required by lettuce includes that used by the crop for evapotranspiration (ET) and an amount to leach out excess salts known as the leaching requirement (LR). Lettuce is a salt sensitive crop and irrigation with Colorado River water diverted at Imperial Dam would have a LR of at least 20% ET.

Paramount to efficient irrigation management is accurate estimates of lettuce ET and the tools to use these estimates. The depletion of soil moisture by crops can be measured directly by soil-sensing devices or estimated from weather-based ET measurements. Specific crop evapotranspiration (ETc) is calculated from the reference evapotranspiration (ETo) and crop coefficients (Kc), with ETo being calculated using weather based equations (eg.Penman Monteith or others). We have developed, and are continuing to develop, criteria for scheduling irrigations in the Lower Colorado River Basin (LCRB) (Martin et al., 2003; Brown, 2005) and currently use crop coefficients for cotton irrigation scheduling. However, work is needed to develop accurate crop coefficients for more of the diverse vegetable crops produced in the desert. Gallardo et al. (1996) developed a model to estimate ETc of iceberg lettuce planted in the soil using only ETo data as an input parameter. While this model was validated in the central coast of California we do not have any data to validate its utility in the desert.

Over the past decade there have been significant advances in technologies to measure crop ET under field conditions. One such technology is Eddy Covariance (ECV). Eddies are turbulent airflow caused by wind, the roughness of the Earth's surface, and convective heat flow at the boundary between this surface and the atmosphere. ET occurs when water vapor in upward moving eddies is greater than in downward moving eddies. Sensible heat is positive when upward moving eddies are warmer than downward moving eddies. Water vapor, heat, and carbon dioxide transferred by eddies can be measured directly using ECV. The ECV method is now a well-established, standardized, and state-of-the-art approach for measuring ET, and results from ECV stations are considered reference quality.

In past years, AILRC has funded research on water and salt balance for both the lettuce stand establishment irrigation and the thinning irrigation. Our objective for 2017-2018 was to obtain accurate measurements of the evapotranspiration of lettuce in Yuma, AZ. When combined with past research on lettuce and a larger ongoing multi-year water/salt balance research project, this data will enhance the data set needed for future development of mobile irrigation Apps to help growers make more-efficient irrigation decisions.

Materials and Methods

Six field sites were utilized to measure ET in lettuce production systems in 2017-2018. Planting dates ranged from September through November, 2017. In all experiments we used Eddy Covariance systems (Figure 1). ECV obtains ET by measuring incoming and outgoing energy fluxes over the cropped landscape. The ECV measures four energy flux components- net radiation (Rn), ground heat flux (G), sensible heat flux (H), and latent heat flux (LE). Rn represents absorbed solar and infrared radiation, G is heat transported into the soil, H is turbulent heat above the crop due to air temperature gradients, and LE is latent heat energy due to ET. While ET can be estimated from just the LE component, accurate estimates require collecting all four components. ECV data values are reported in energy flux units (W/m^2), with water-specific quantities also reported as depths over time (e.g. mm/day).

Each ECV system requires sensors, one or more data loggers, power supplies, and mechanical supports. Sensors measure air temperature, humidity, wind speed, wind direction, water vapor concentration, CO_2 concentration, soil temperatures, soil moisture, solar and infrared radiation, all at sample rates up to 20 Hz. Data loggers collect, analyze, and store analog and digital signals from the sensors; in some cases they are connected to a cellphone modem for transmitting synopses of data and system health information to one of our home offices. Power supplies consist of 12V batteries, voltage regulators, grounding rods, and solar panels. The mechanical supports include tripods, masts, lightning rods, anchors, and guy wires to ensure the sensors, loggers, and power supplies remain accurately aligned in all weather conditions. The dates for study sites are shown in Table 1.

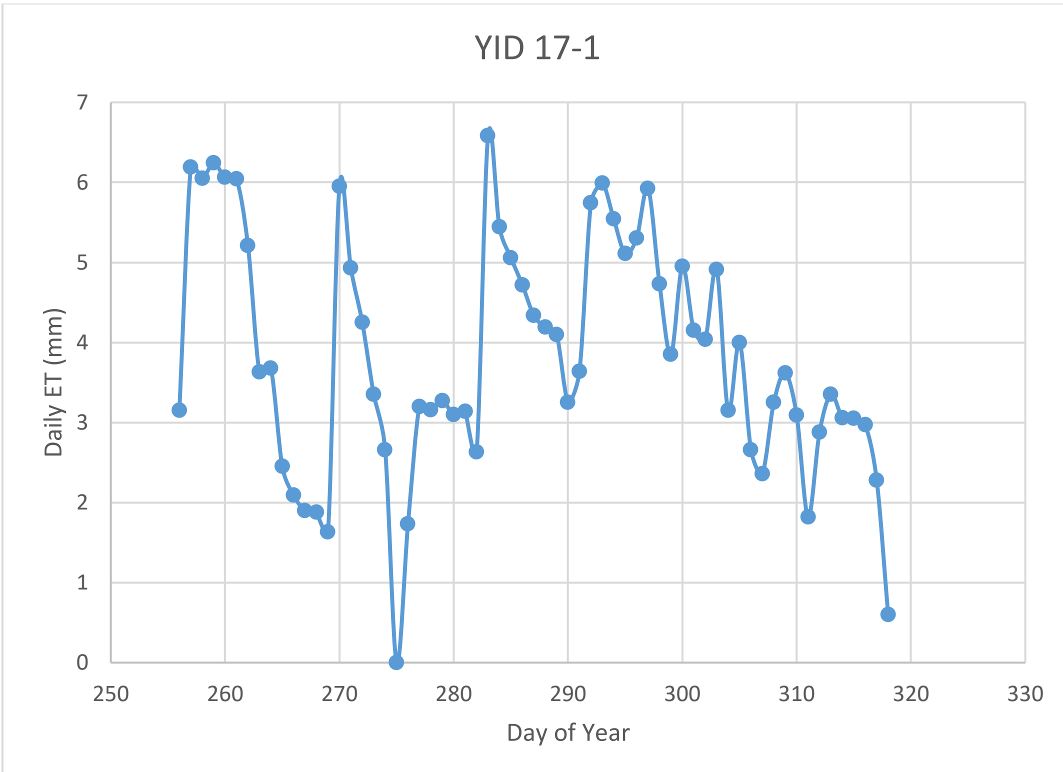
Results and Discussion

Daily and cumulative seasonal ET is shown for all sites in Figures 2 through 7. Measured ET ranged from 241 to 310 mm (9 to 12 inches). Interestingly, these are higher values than the 6 to 9 inch range used by the United States Bureau of Reclamation to estimate water use. Most ET data currently used in the low desert was generated over 50 years ago and may not reflect current production outcomes. Yields have increased by 65% over the past four decades. It seems water use may increase approximately 50 mm between the earliest and latter plantings. We hope to verify this trend in 2018-2019. These data provide reliable ET estimates aligned with current lettuce production practices and will serve as a basis for revised crop coefficients. Furthermore, the data collected for the objectives of this report will be combined with data collected in 2016-2017, and currently being collected in 2018-2019, to calibrate ET models based on space-based sensors, which is an objective of our 2018 proposal.

Field	Wet Dates	Deployment Dates	Station Removal	Harvest Dates
YID 17-1	Sept. 11, 2017	Sept. 13, 2017	Nov. 14, 2017	Nov. 13, 2017
YID 17-2	Sept. 21, 2017	Sept. 21, 2017	Dec. 04, 1207	Dec. 04, 2017
YID 17-3	Sept. 24, 2017	Sept. 24, 2017	Dec. 05, 2017	Nov. 27, 2017
YID 17-4	Oct. 06, 2017	Oct. 06, 2017	Dec. 28, 1207	Jan. 03, 2018
YCWUA 17-1	Nov. 11, 2017	Nov. 12, 2017	Feb. 16, 2018	Feb. 19, 2018
YCWUA 17-2	Nov. 18, 2017	Nov. 19, 2017	Mar. 05, 2018	Mar. 05, 2018

Table 1. Dates of study for six sites in 2017-2018.

Figure 1. Eddy Covariance system in a lettuce field during the 2017-2018 season.



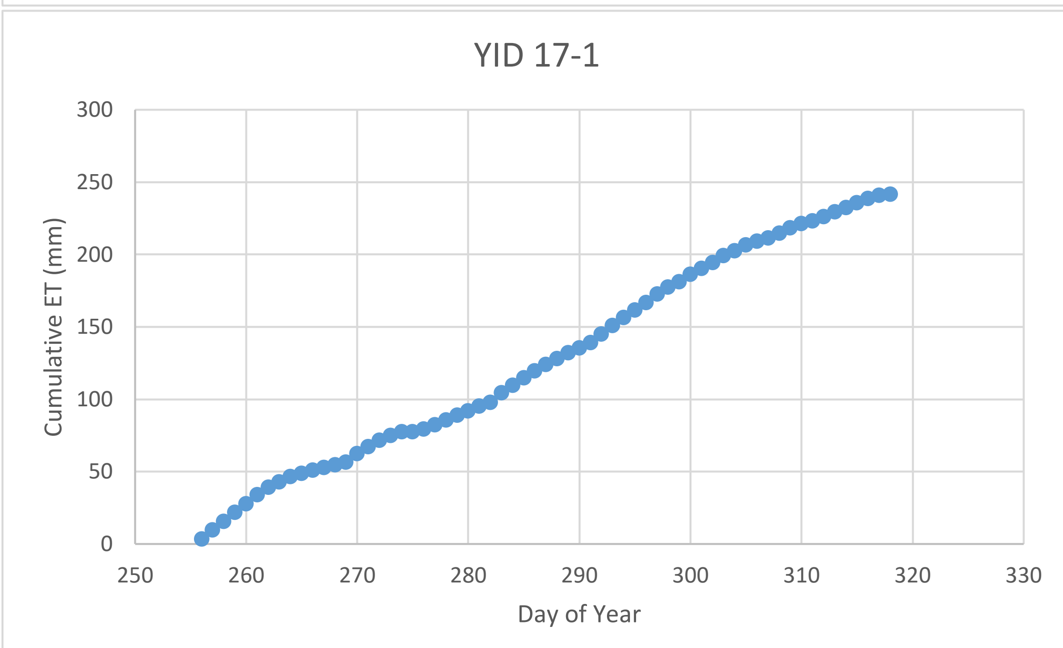
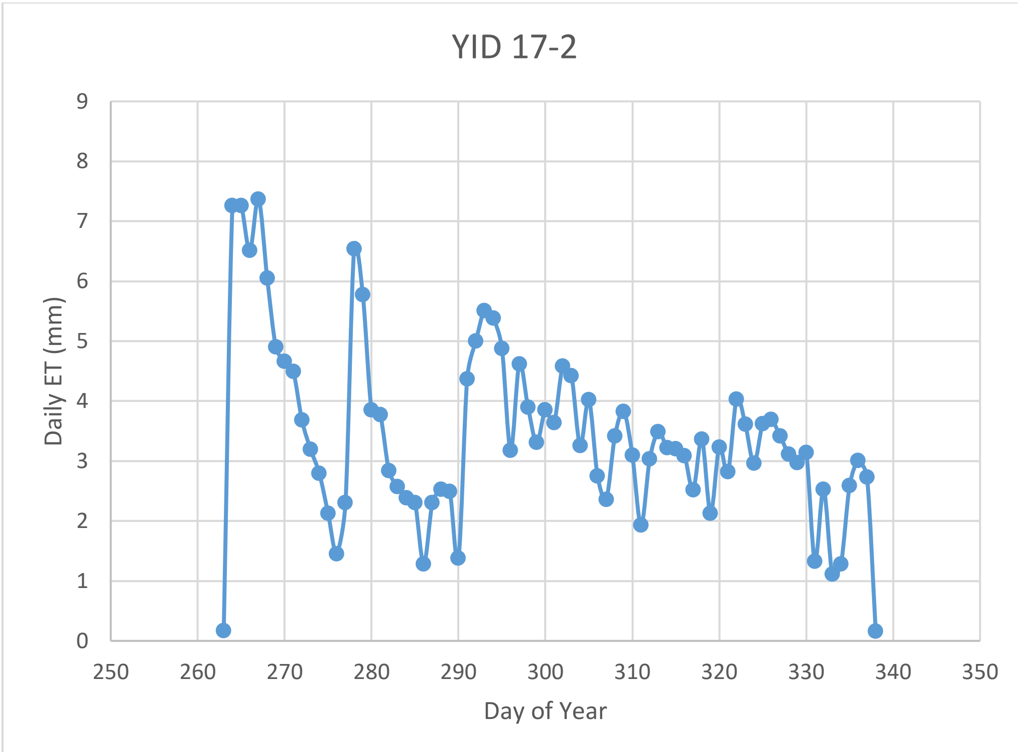


Figure 2. Measured daily and cumulative ET for YID 17-1.



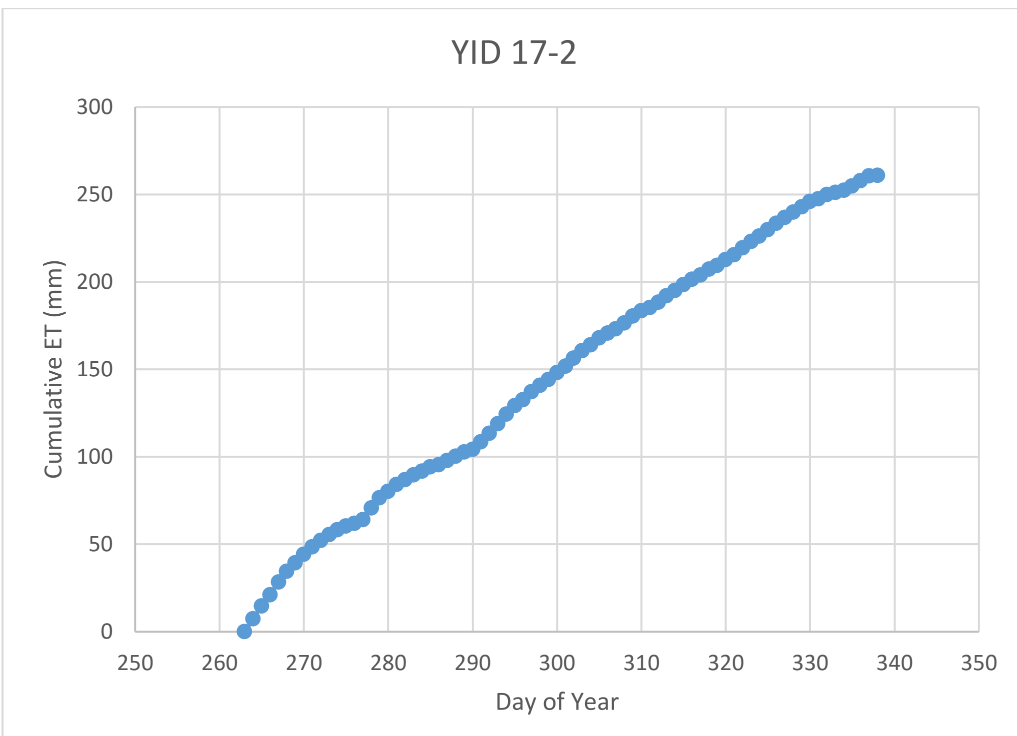
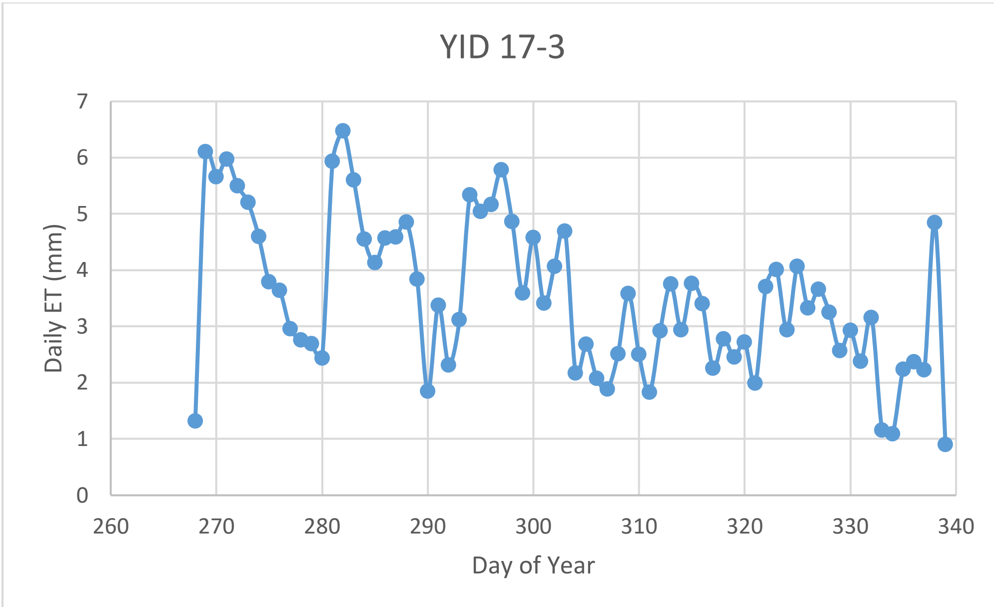


Figure 3. Measured daily and cumulative ET for YID 17-2.



.

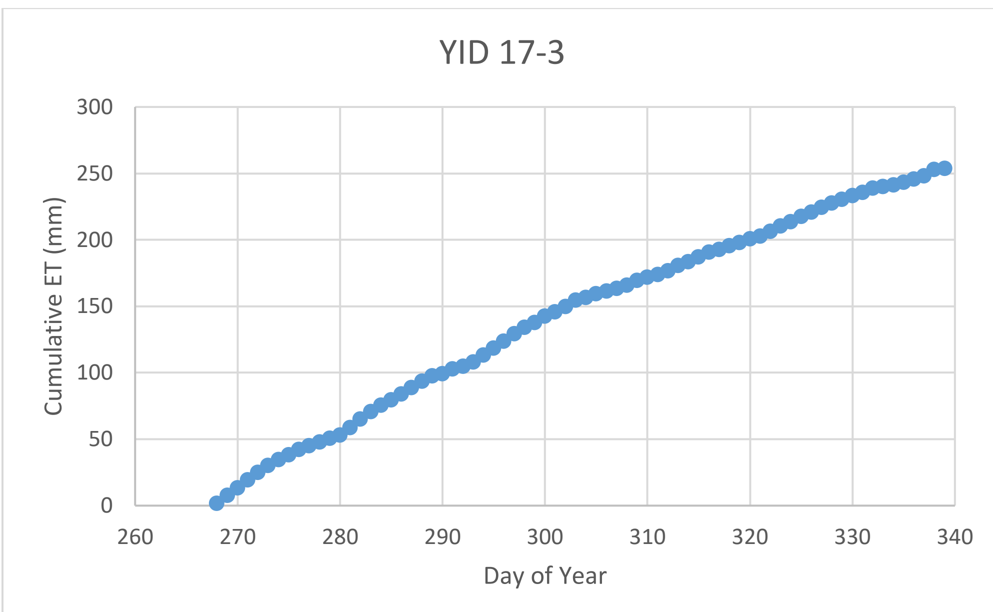
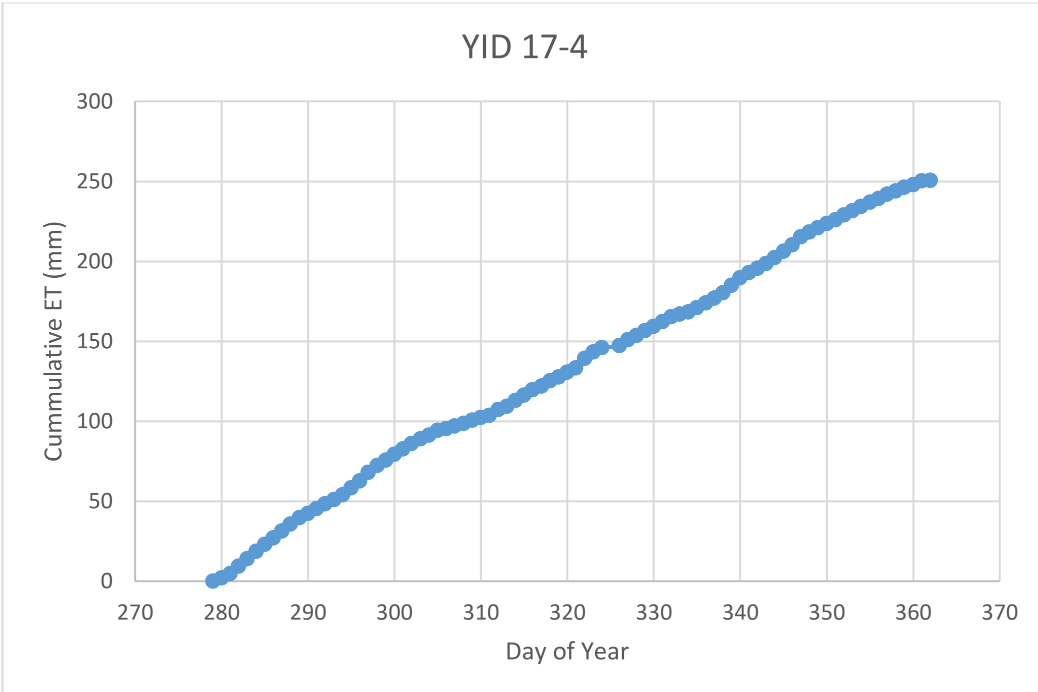


Figure 4. Measured daily and cumulative ET for YID 17-3.



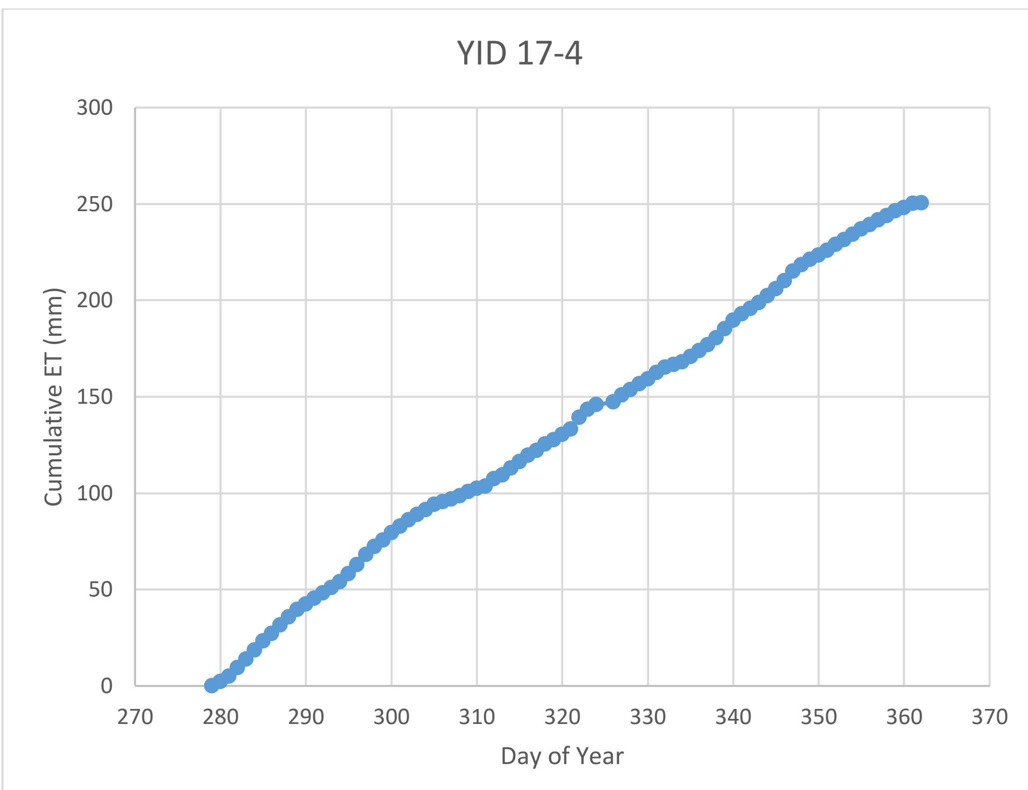
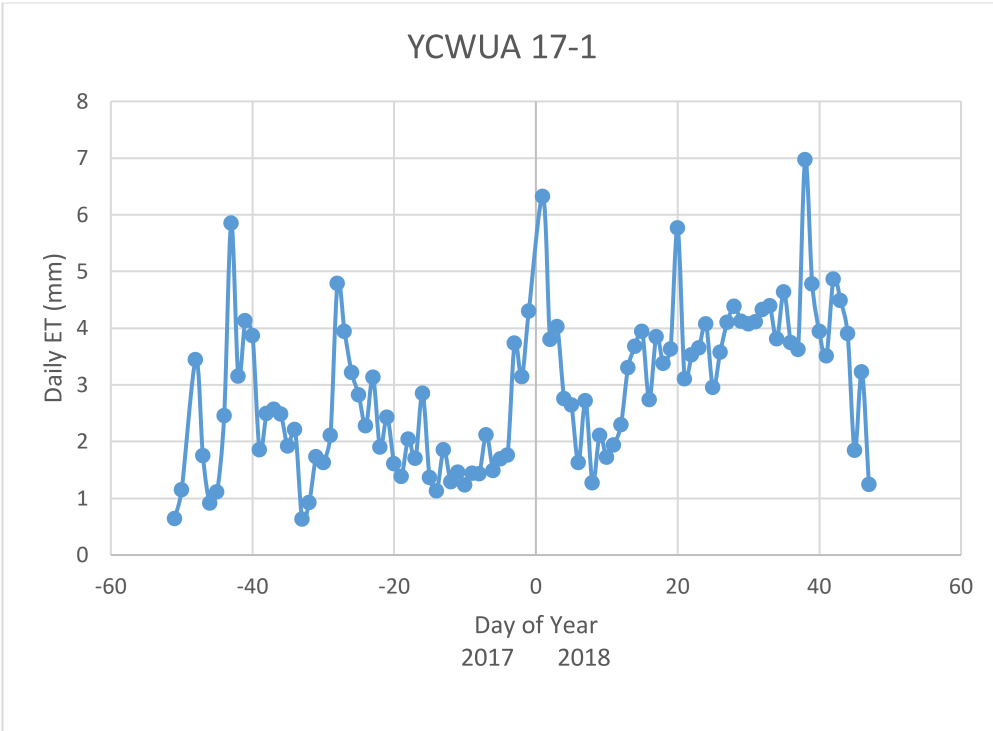


Figure 5. Measured daily and cumulative ET for YID 17-4.



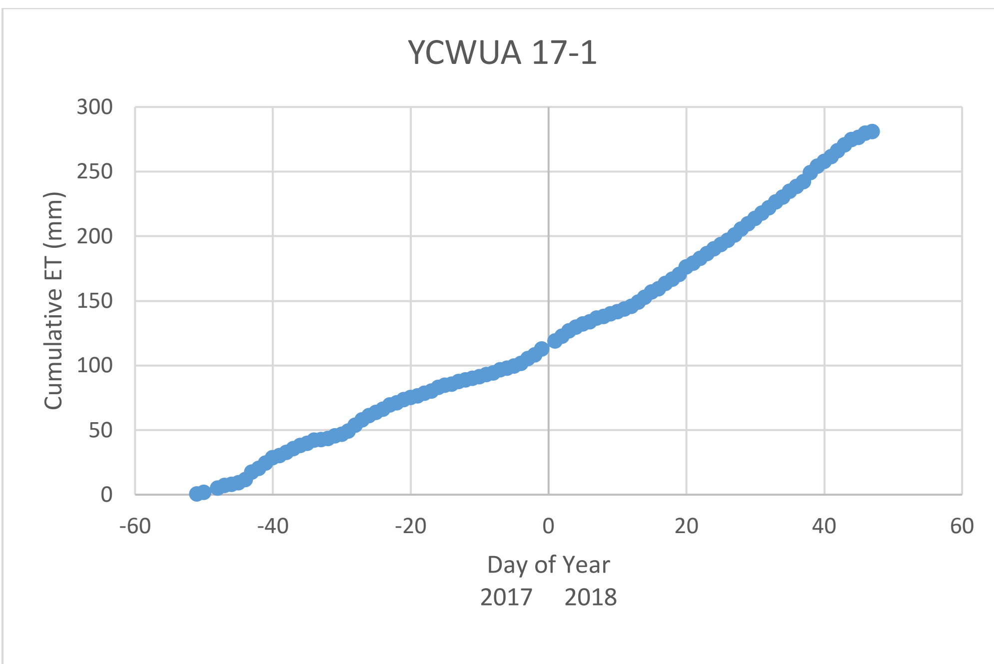
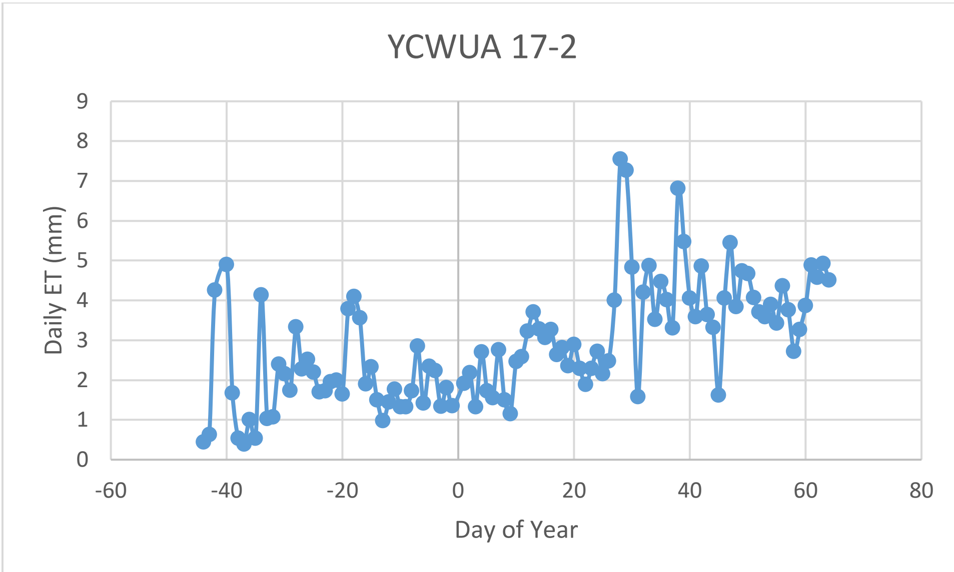


Figure 6. Measured daily and cumulative ET for YCWUA 17-1.



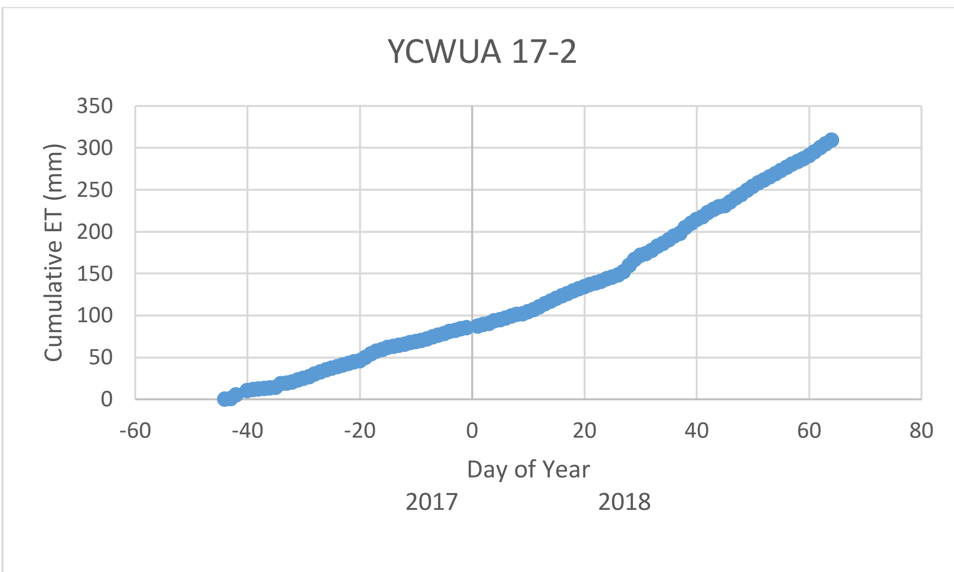


Figure 7. Measured daily and cumulative ET for YCWUA 17-2.