Drought Monitoring Tools for Arizona Rangelands

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The University of Arizona

Brief Project Overviews

- Tools and strategies for ranch-scale drought detection
- Developing a drought monitoring playbook for Arizona rangelands

Developing tools and strategies for ranch-scale drought detection

Project Team

- Mike Crimmins – UA SWES, CLIMAS
- Mitch McClaran – UA SNRE
- Julie Brugger – UA SNRE
- Kelsey Hawkes – UA SNRE

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Project Partners

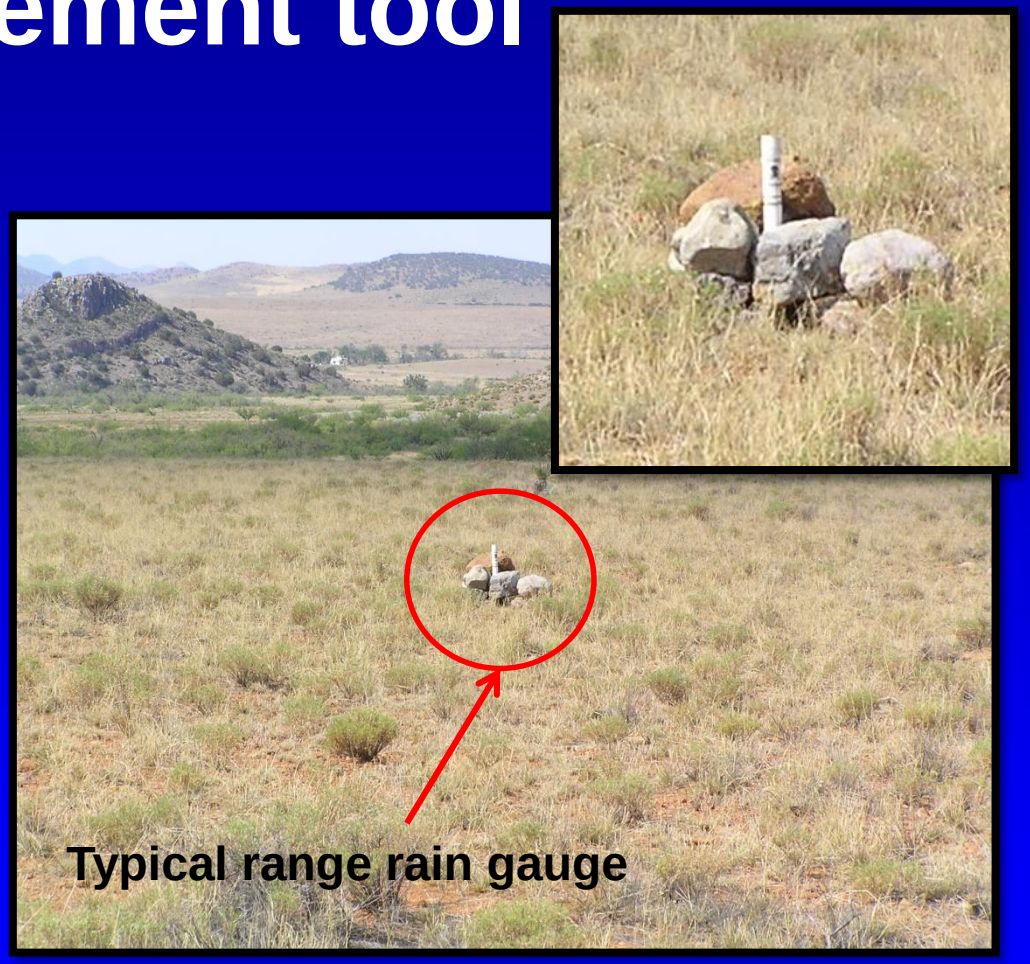
Project supported by:

USDA ***SW Regional Climate Hub***

Precipitation monitoring is key management tool

"What type of information would help drought planning and management? ***Rain gauges***. Some ranchers have them but don't read them. Some have only a home. Would like to see a couple per pasture"

- USFS Rangeland Mgmt Specialist



A rain gauge in every pasture and allotment

- ***Precipitation observations can mitigate land management conflicts - need to be trusted by both parties***
- Precipitation data used in evaluating rangeland conditions relative to grazing operations
- UofA Extension has been working to develop best practices in constructing, placing and reading gauges and managing/utilizing observations

PVC depth gauge at range monitoring site near Clifton, AZ

Precipitation Monitoring Working Group
(Gila County Cattlegrowers, USFS, AZ Game/Fish, BLM)

Workshop 1 (June 2016)
- Learn about rain gauge monitoring strategies, provide feedback, and help guide the scoping of online tools
- Receive several rain gauges to install and monitor over the 2016 monsoon season.

Monsoon Season

Workshop 2 (Nov 2016)
- Review rainfall observations, test new online tools, and share lessons learned
- Co-develop training materials, best practices and finalize online tools to share with other ranchers and land managers.

Workshop 3 (June 2017)
- Open training workshop using materials and best practices developed
- Encourage others to establish new rain gauges and use the new software to archive and analyze the newly collected rainfall data.

Project supported by:

WESTERN EXTENSION RISK MANAGEMENT EDUCATION
Serving Farmers and Ranchers Through Targeted Risk Management Education
http://westrme.wsu.edu/

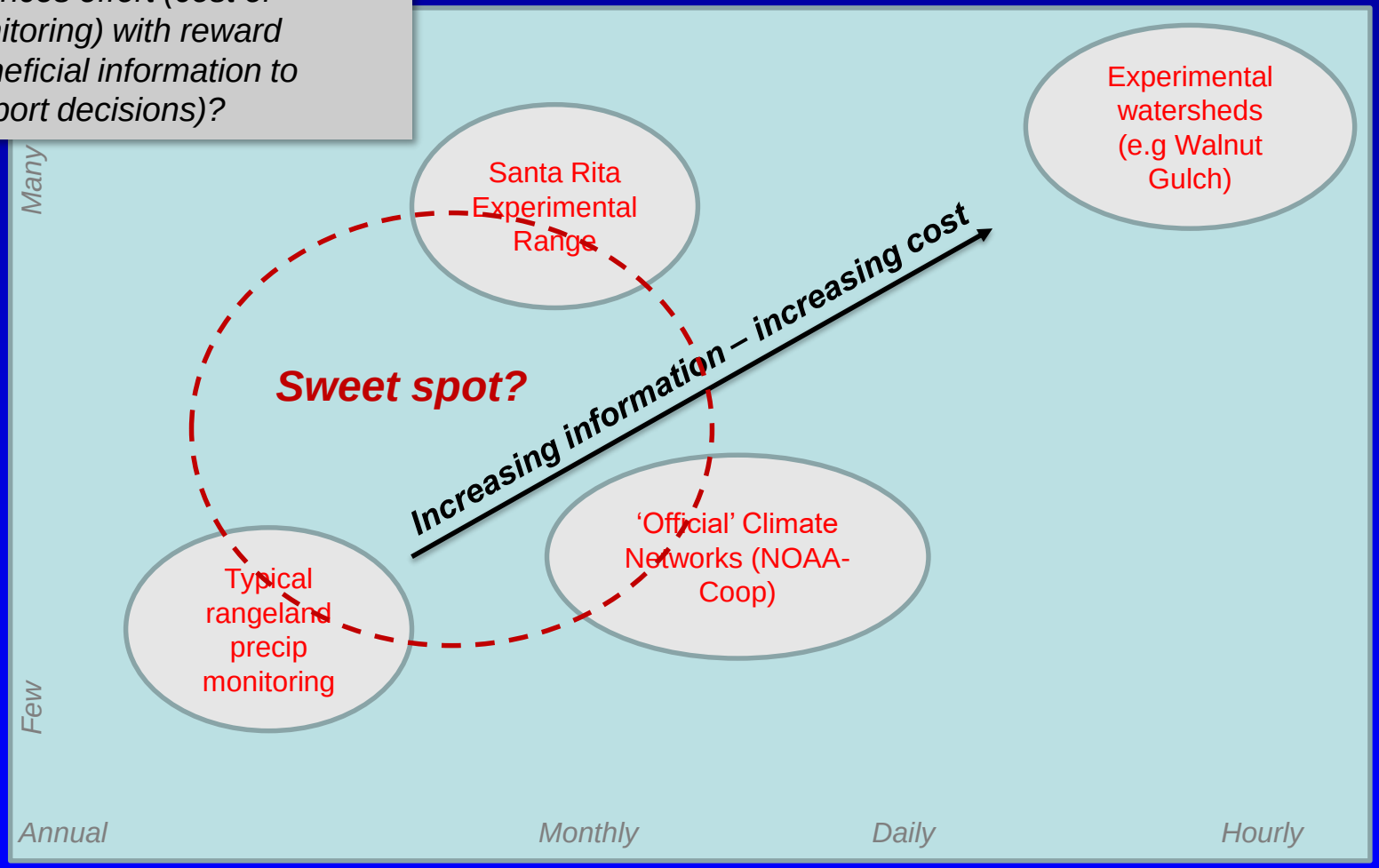
USDA
SW Regional Climate Hub

What are “best practices” in range precip monitoring?

- More is better, but need to tie to range monitoring and decision making – ***Where?***
- More frequent reading of gauges will yield important information on ‘tank’ vs. ‘grass’ rains – ***When?***
- What is ‘normal’ for a rain gauge without a long-term record? – **What does it mean?**

Developing a precipitation monitoring plan

Where is the 'sweet spot' that balances effort (cost of monitoring) with reward (beneficial information to support decisions)?



Simple rain gauges for range monitoring

Yavapai County

ARIZONA COOPERATIVE EXTENSION

COLLEGE OF AGRICULTURE AND LIFE SCIENCES

Simple Design for a Remote Rain Gauge

By: Jeff Schalau, Associate Agent, ANR
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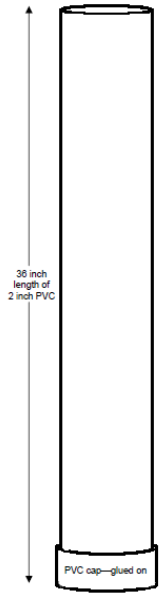


Precipitation data is often useful in making land management decisions. However, sites of interest are often in remote areas that are visited infrequently. Below are instructions for building an inexpensive precipitation gauge and how to take seasonal measurements on remote sites. The precipitation gauge is made from a 36-inch length of 2 inch PVC pipe that has a PVC cap glued onto one end. The pipe is then hose clamped open-end-up to a fence post or T-post.

Make sure to locate the gauge away from trees, buildings, power lines, and other features that may reduce the accuracy of data collected. After securing the gauge to the post, place a small volume (2 to 3 inches) of a 50:50 mix of antifreeze and automatic transmission fluid. The ATF keeps the captured water from evaporating and the red color of the ATF makes it easy to read on a tape measure. The antifreeze keeps the water from freezing.

Measurements should be recorded following winter (usually collected in June) and summer precipitation (usually collected in early October). More frequent readings (i.e monthly or quarterly) may collected when justified. At each site, depth readings are taken, giving the amount of precipitation since the last reading. The gauge should be cleaned and replenished at least once per year. It is also a good idea to put a piece of hardware cloth inside the opening to prevent birds, rodents, and other small animals from entering the pipe.

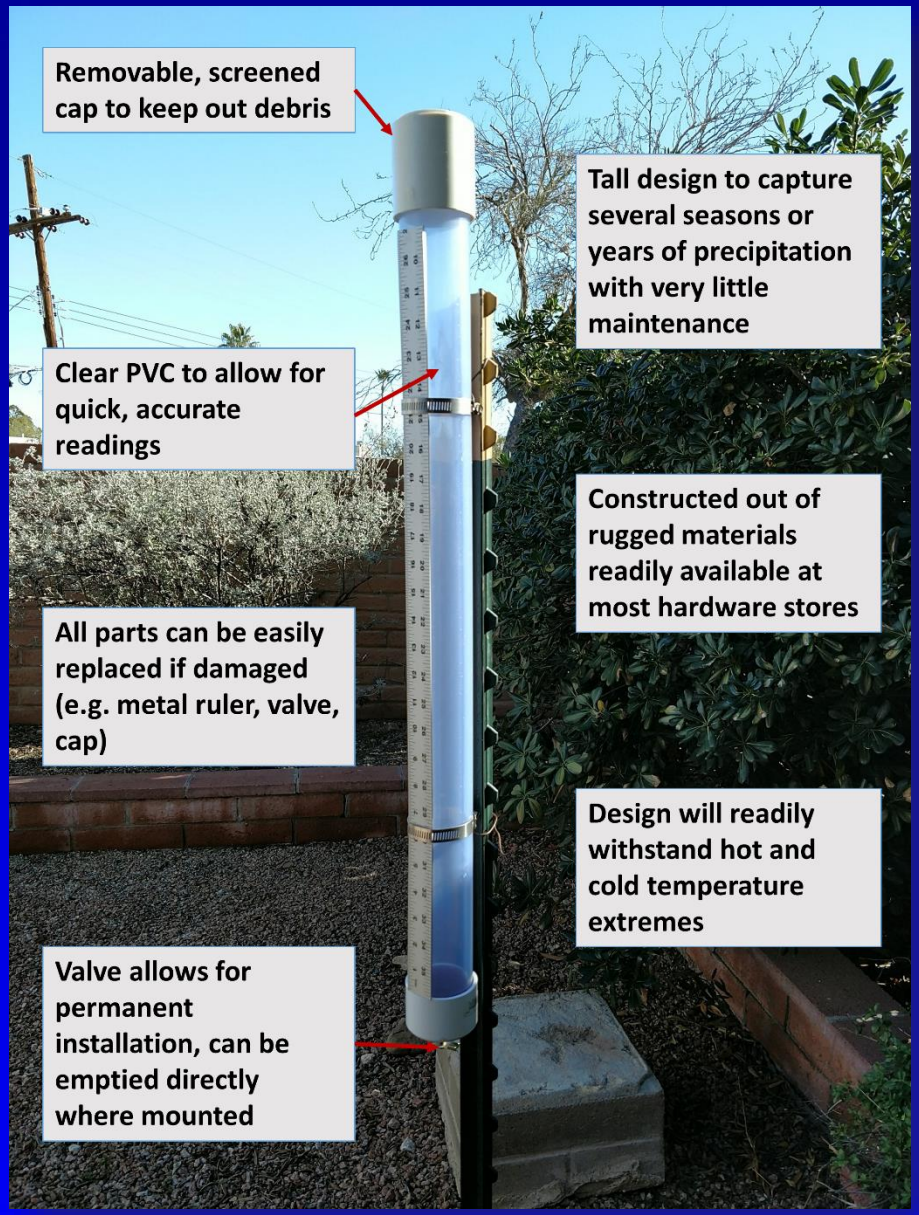
On grazing allotments managed by state or federal agencies, it is a good idea to locate several precipitation gauges distributed across the management unit. Many ranchers that have permanent monitoring sites place these gauges at each site. Some users of these gauges have camouflaged them to decrease the likelihood of vandalism.

Can we design a better rain gauge for remote, range monitoring?: 'Cow proof', easy to read and maintain, inexpensive, rugged and long-lasting…


George
Martin

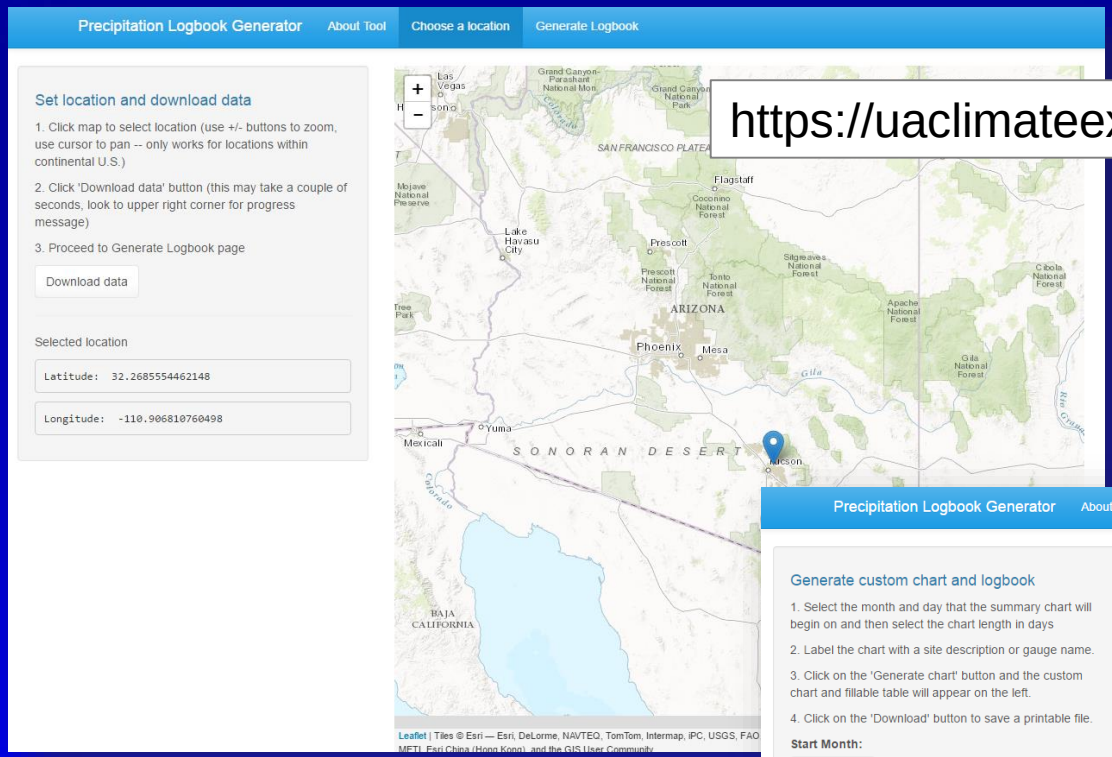

07/26/2016

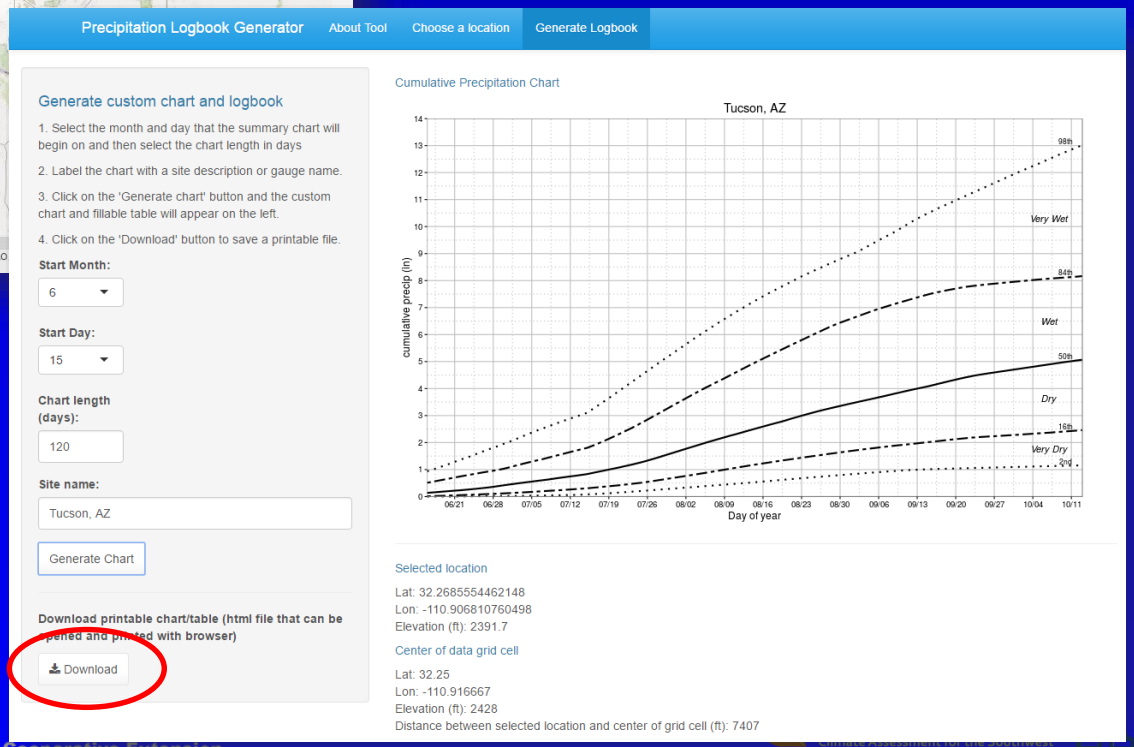
Accumulation Precipitation Gauge



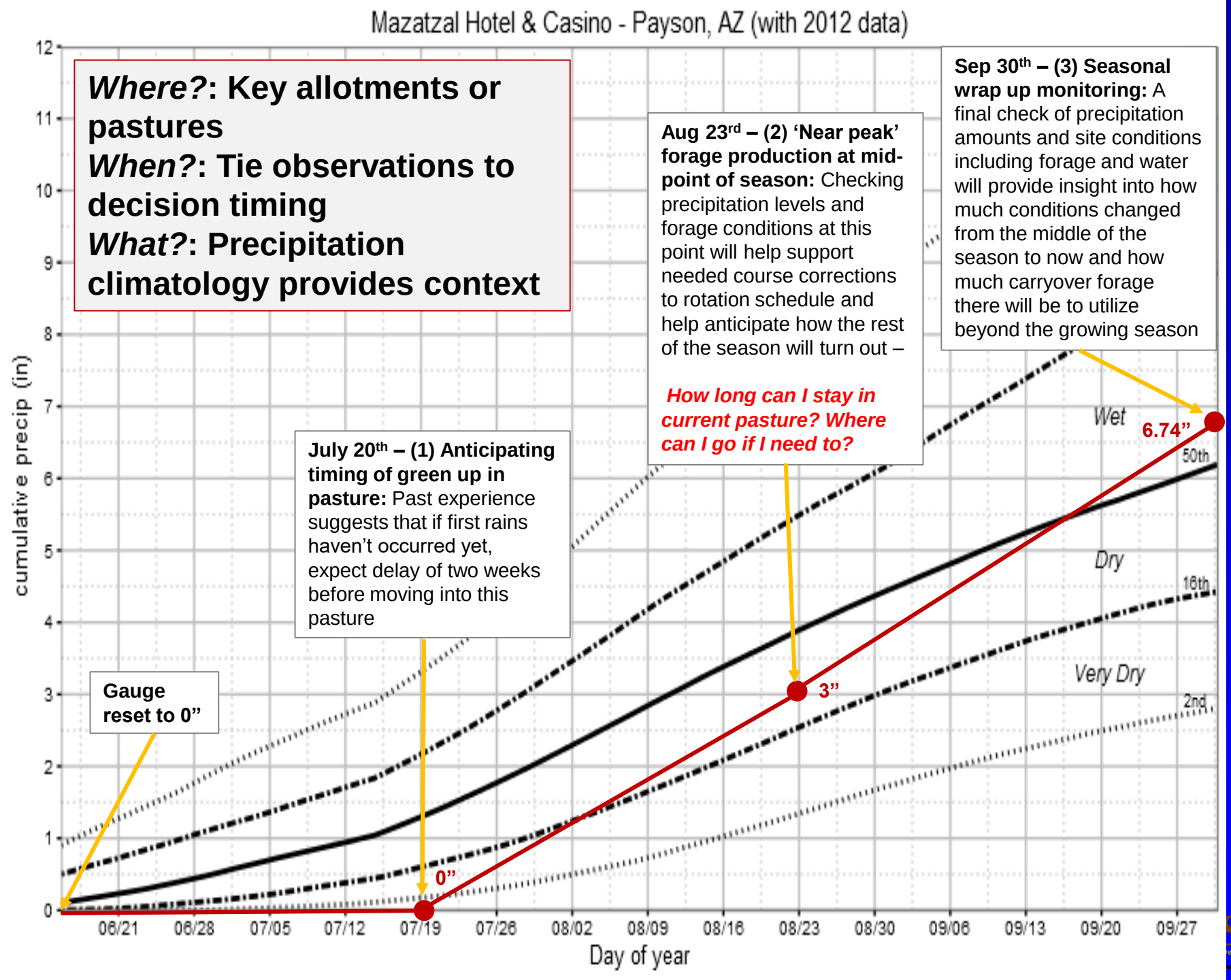
Supporting tools and resources

https://uaclimateextension.shinyapps.io/precipChart/

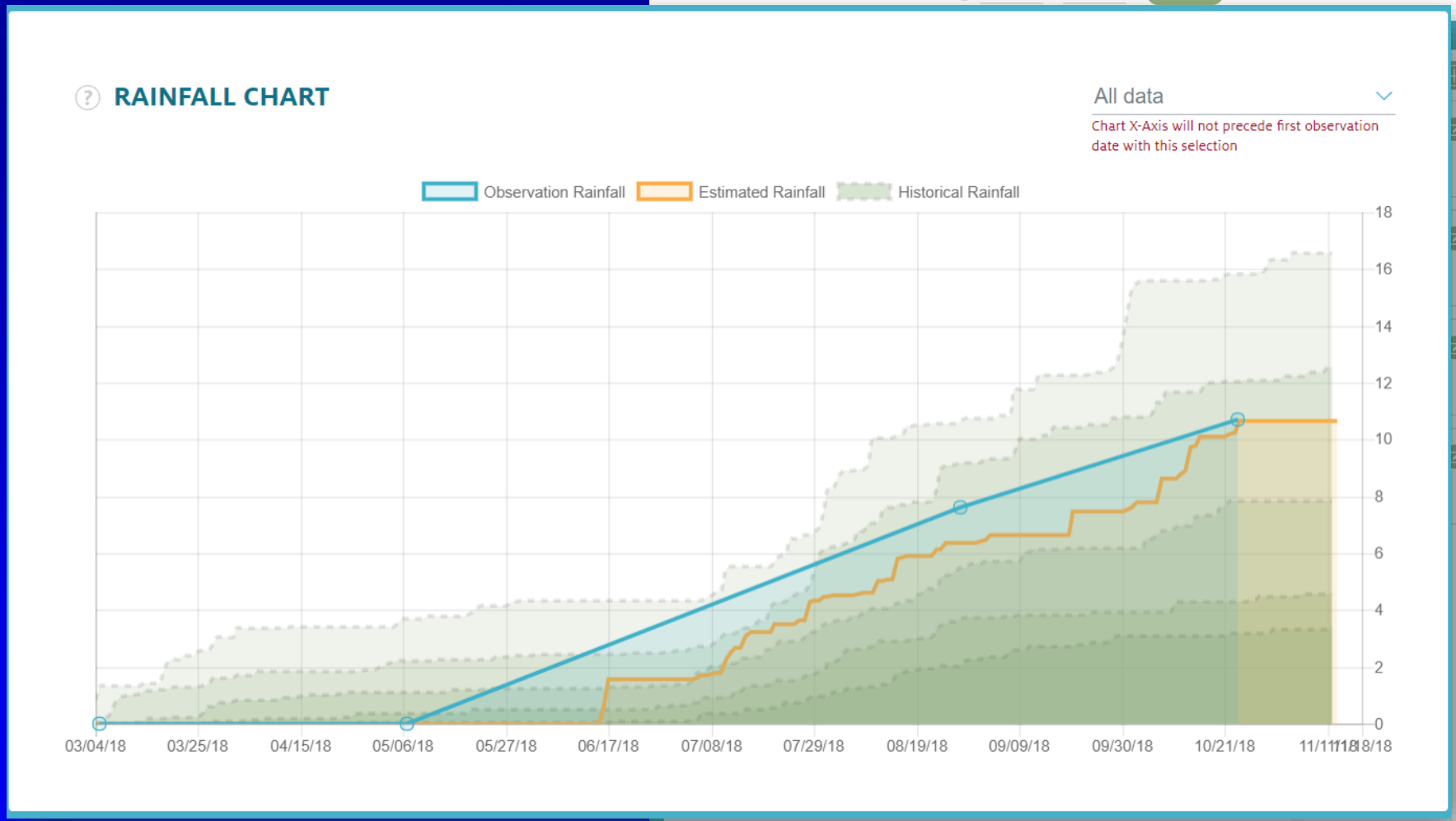




Precipitation Logbook Generator

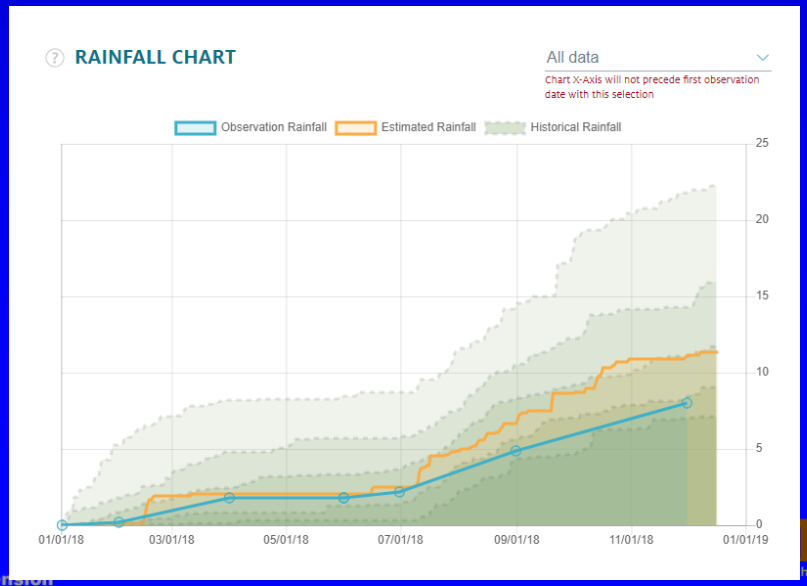

Mazatzal Hotel & Casino - Payson, AZ (with 2012 data)
Where?: Key allotments or pastures
When?: Tie observations to decision timing
What?: Precipitation climatology provides context
Aug 23rd – (2) 'Near peak' forage production at mid-point of season: Checking precipitation levels and forage conditions at this point will help support needed course corrections to rotation schedule and help anticipate how the rest of the season will turn out –
How long can I stay in current pasture? Where can I go if I need to?
Sep 30th – (3) Seasonal wrap up monitoring: A final check of precipitation amounts and site conditions including forage and water will provide insight into how much conditions changed from the middle of the season to now and how much carryover forage there will be to utilize beyond the growing season
July 20th – (1) Anticipating timing of green up in pasture: Past experience suggests that if first rains haven't occurred yet, expect delay of two weeks before moving into this pasture
Gauge reset to 0"
Wet
50th
Dry
16th
Very Dry
2nd
6.74"
3"
0"
cumulative precip (in)
Day of year
06/21
06/28
07/05
07/12
07/19
07/26
08/02
08/09
08/16
08/23
08/30
09/06
09/13
09/20
09/27

Supporting tools and resources



Working to continue to expand monitoring through hands-on workshops…

Rain Gauge Workshop – Clifton, AZ Dec 2018



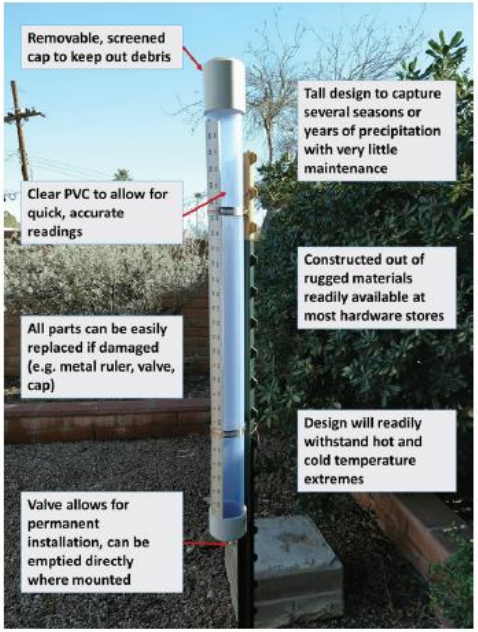
Rain Gauge Construction Guide (UA Extension Bulletin)

THE UNIVERSITY OF ARIZONA
COLLEGE OF AGRICULTURE & LIFE SCIENCES
Cooperative Extension

az1747 September 2017

Do-it-yourself construction guide: Rugged accumulation precipitation gauge for remote monitoring

Michael A. Crimmins, Mitchel McClaran, Julie Brugger, Ashley Hall and Douglas Tolleson



Introduction

Precipitation is the key variable in assessing drought status and tracking changes in drought conditions. Precipitation

unattended site? A simple and inexpensive accumulation gauge can help in this situation. These gauges are typically

https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1747-2017_0.pdf

Precip Monitoring Best Practices Guide (UA Extension Bulletin)

THE UNIVERSITY OF ARIZONA
COLLEGE OF AGRICULTURE & LIFE SCIENCES
Cooperative Extension

az1751 November 2017

Rain Gauges for Range Management: Precipitation Monitoring Best Practices Guide

Michael A. Crimmins, Mitchel McClaran, Julie Brugger, Ashley Hall, Douglas Tolleson and Andrew Brischke

Introduction

Precipitation in the form of rain and snow is critical to many aspects of working lands from controlling the growth of vegetation used in grazing by livestock and wildlife to recharging local water resources found in springs, tanks and riparian areas. Land management decisions often require some knowledge of how much precipitation fell within a management unit to assess how past actions have performed and what to do next. For example, do forage conditions reflect a lack of precipitation or grazing management? Did the next pasture or allotment in my rotation get any rainfall over the past season?

Given that precipitation monitoring is important, where and how do we usually get this information? Typically, we consult websites and maps that track precipitation observations from airports and backyard observers. These 'official' sites, managed by volunteer and federal agency programs, do a good job of maintaining a steady stream of high quality data, but often are located near cities away from rural and backcountry areas where the bulk of land management activities occur. Estimates provided by interpolating between these official gauges can provide just that, estimates. Knowing how much and when precipitation fell in your pasture, allotment or land management unit is a key variable for sound decision making and requires collecting precipitation data directly at that site.

Overall, this "best practices" guide will cover some of the basic approaches to collecting and using precipitation observations at remote sites in support of rangeland management including:

- Tying observations to a drought plan
- Where to place gauges and how often to record observations
- Managing and using precipitation observations

This guide will also highlight some new tools that help put

piece of information to support a management decision.

Figure 1. Clear PVC rain gauge (photo courtesy of J. Lyman)

Rain gauges

Precipitation monitoring is one of the most straightforward aspects of weather and climate monitoring and does not require overly sophisticated or expensive equipment. Simple rain gauges consisting of a collection container suffice under most situations. Gauges made out of PVC tubes capped at one end and mounted to fence posts in key areas have been utilized by ranchers and land managers for many years. These gauges typically have a small amount of oil in the gauge to

for direct reading of the precipitation amounts in the gauge

https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1751-2017.pdf

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Natural Resources & the Environment

HOME DASHBOARD TOOLS GUIDES ABOUT US

Drought and Grazing

Introd

Drought threa… water resources for …table.

Planning for … collaboration …

Since 2013, … monitor drought cond… …nning where ever it is nee…

Goal

Improve the p…

Approach

Develop drought information tools and guides to monitor drought, and integrate those tools and guides to support collaborative drought planning by ranchers and Forest Service staff.

Upcoming training workshops

- Willcox: April 16th
- Show Low: August 14th
- Flagstaff: TBD
- Kingman: TBD

https://cals.arizona.edu/droughtandgrazing/

COLLEGE OF AGRICULTURE & LIFE SCIENCES Cooperative Extension

NOAA

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

GILA COUNTY CATTLE GROWERS ASSOCIATION

National Drought Mitigation Center

Developing a drought monitoring playbook for Arizona rangelands

Project Team: Trevor McKellar (SWES), Marcel Schaap (SWES), Craig Rasmussen (SWES), Dan Ferguson (UA Inst. for the Environment), Mike Crimmins (SWES)

Funded by NOAA Climate Program Office
Sectoral Applications Research Program & RISA

Leave Feedback

WestWideDroughtTracker

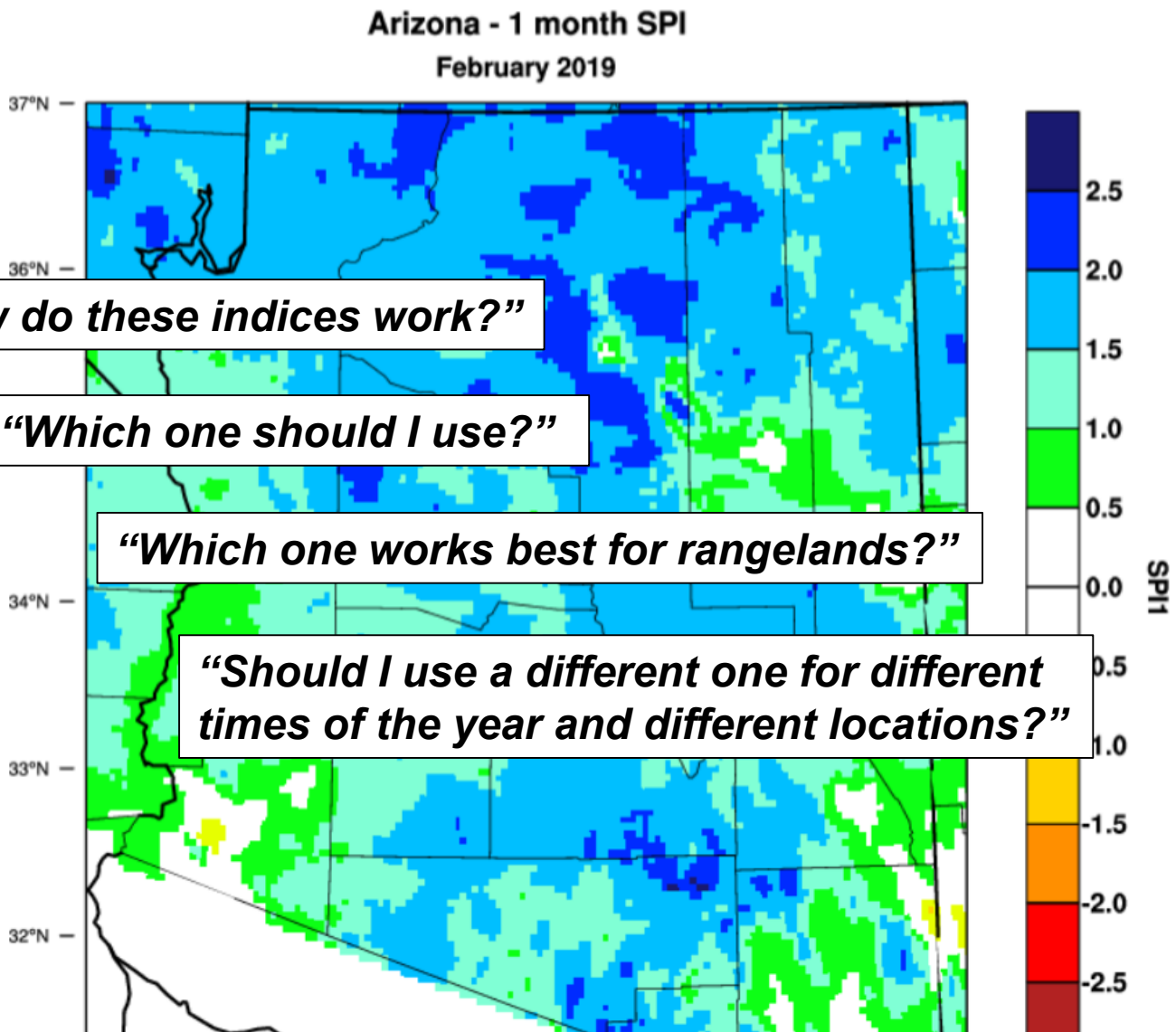
About | Current Maps | Archived Maps | Time Series | Download

Climate Product Options

Expand All | Contract All

- Variable
  - Drought Index
    - Palmer Index
      - PDSI
      - Palmer Z-Index
      - Self-Calibrated PDSI
    - SPI
      - 1 Month
      - 2 Months
      - 3 Months
      - 4 Months
      - 5 Months
      - 6 Months
      - 7 Months
      - 8 Months
      - 9 Months
      - 10 Months
      - 11 Months
      - 12 Months
      - 15 Months
      - 18 Months
      - 24 Months
      - 30 Months
      - 36 Months
      - 48 Months
      - 60 Months
      - 72 Months
    - SPEI
      - 1 Month

Current Product:
PRISM > SPI 1 Month > Arizona



"How do these indices work?"

"Which one should I use?"

"Which one works best for rangelands?"

"Should I use a different one for different times of the year and different locations?"

Soil Moisture vs. Drought Indices

- Soil moisture status is a good indicator of potential drought stress to vegetation, ecosystems…direct link between soil moisture and drought impacts
- Soil moisture monitoring is limited…hard to do, expensive, very few stations
- Can we quantify and leverage any relationships between 'soil moisture memory' and windowed drought indices? →

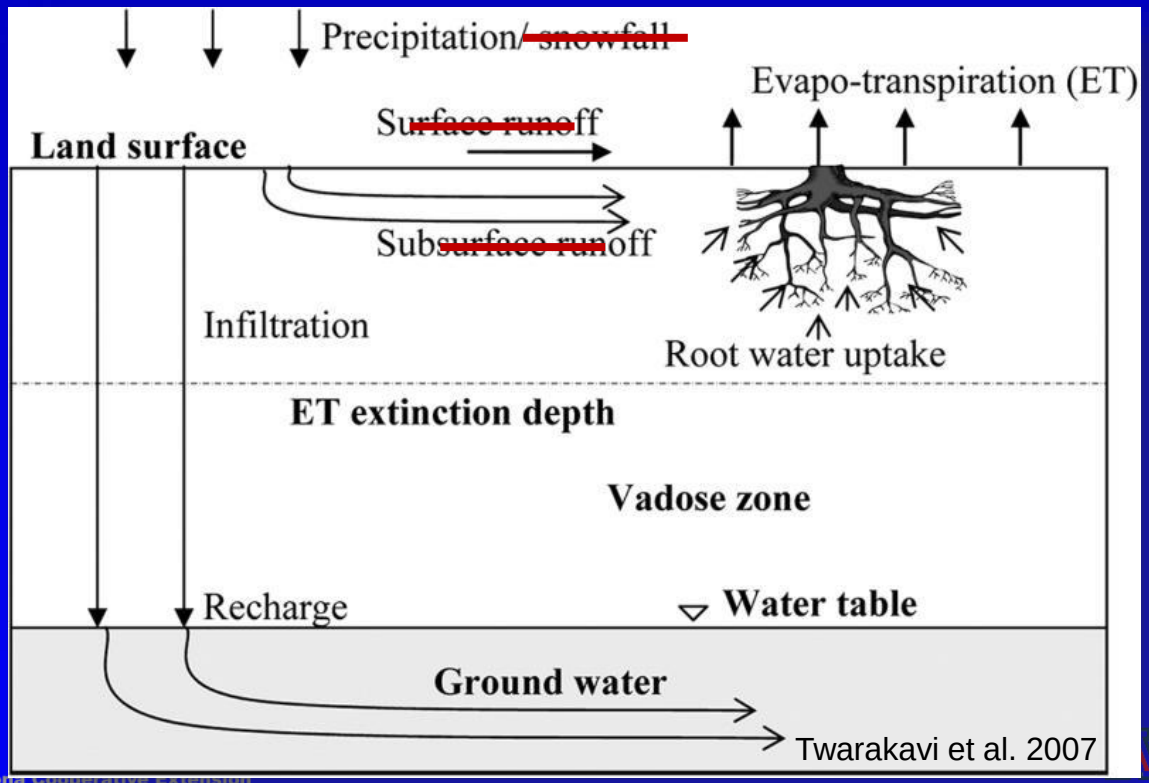
Use modeled soil moisture as an objective measure against which to evaluate simple, readily available indices like SPI, SPEI, PDSI…

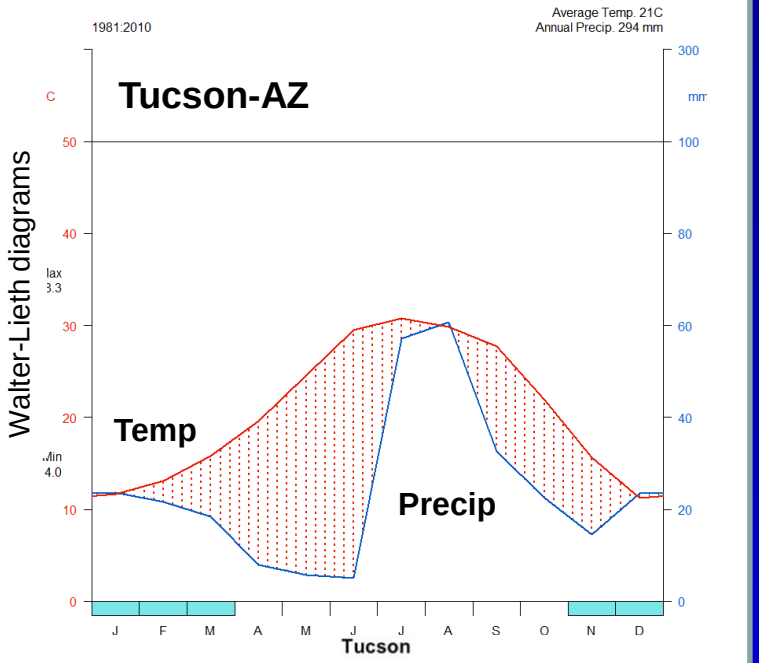
HYDRUS-1D

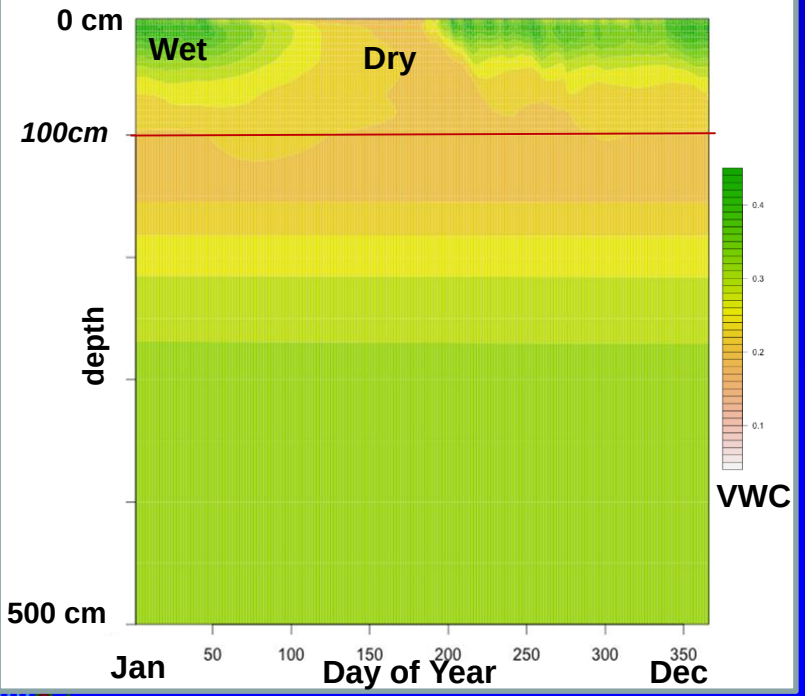
- Numerical soil moisture model that solves the Richards equation for water transport

- Only evaporation/transpiration (Hargreaves or Penman-Monteith estimation) and gravity impact water movement
- Daily temperature and precipitation data
  - 1950-2015 with 10 year spin up

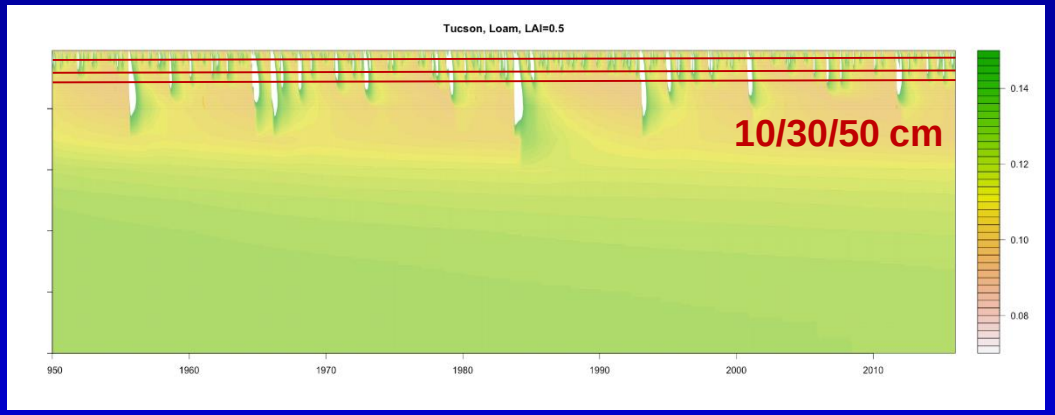
- 500 cm loam (extending to sandy loam and clay)
- 4 study sites (extending to gridded data)



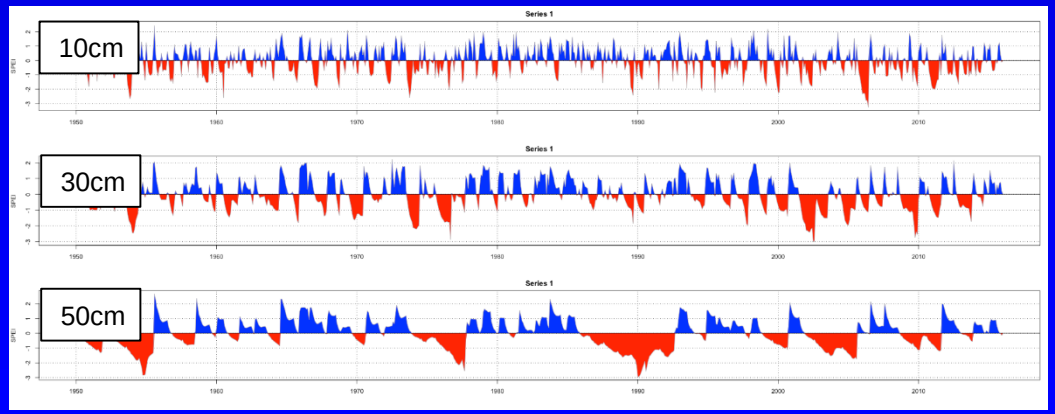




Tucson - Daily Modeled Soil Moisture 1950-2015



Monthly Standardized Soil Moisture Index @ 10/30/50 cm



McKellar 2017

Leave Feedback

About | Current Map | ...acker

Climate Product Options

Expand All | Contract All

- Variable
  - Drought Index
    - Palmer Index
    - SPI
      - 1 Month
      - 2 Months
      - 3 Months
      - 4 Months
      - 5 Months
      - 6 Months
      - 7 Months
      - 8 Months
      - 9 Months
      - 10 Months
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    - SPEI
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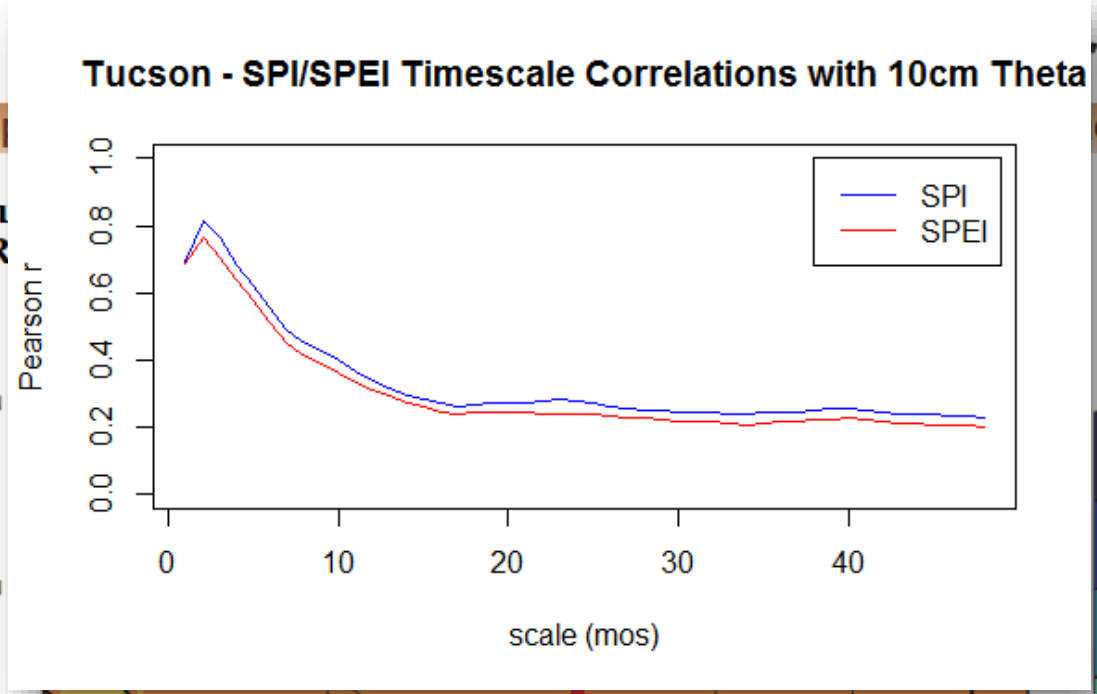
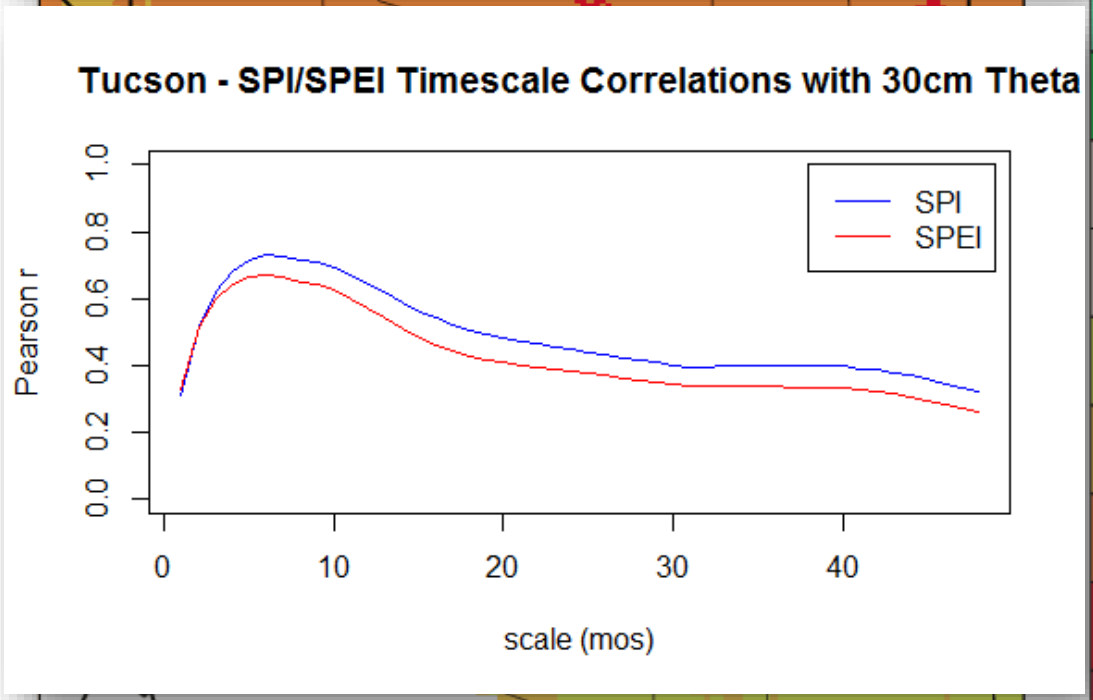
      - 3 Months
      - 4 Months





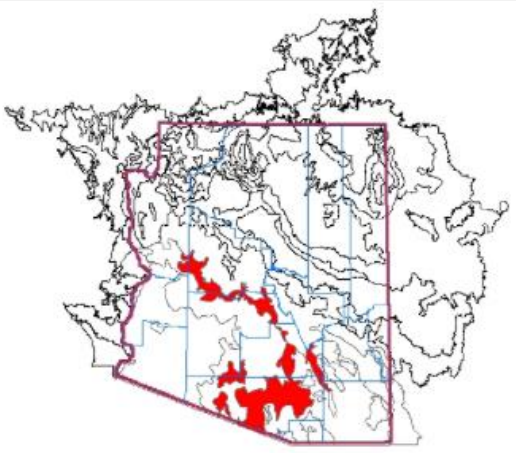
37°N
36°N
35°N
34°N
33°N
32°N

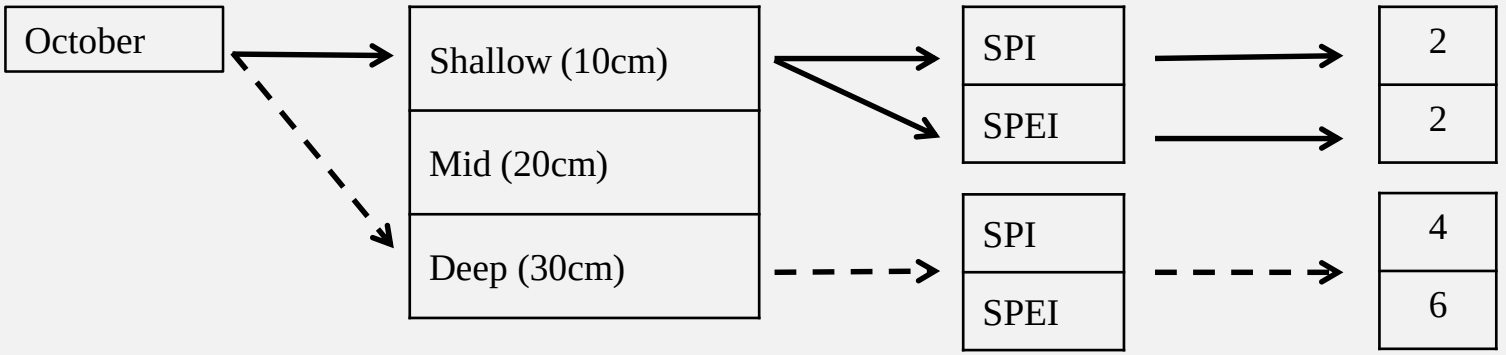
SPI2
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5

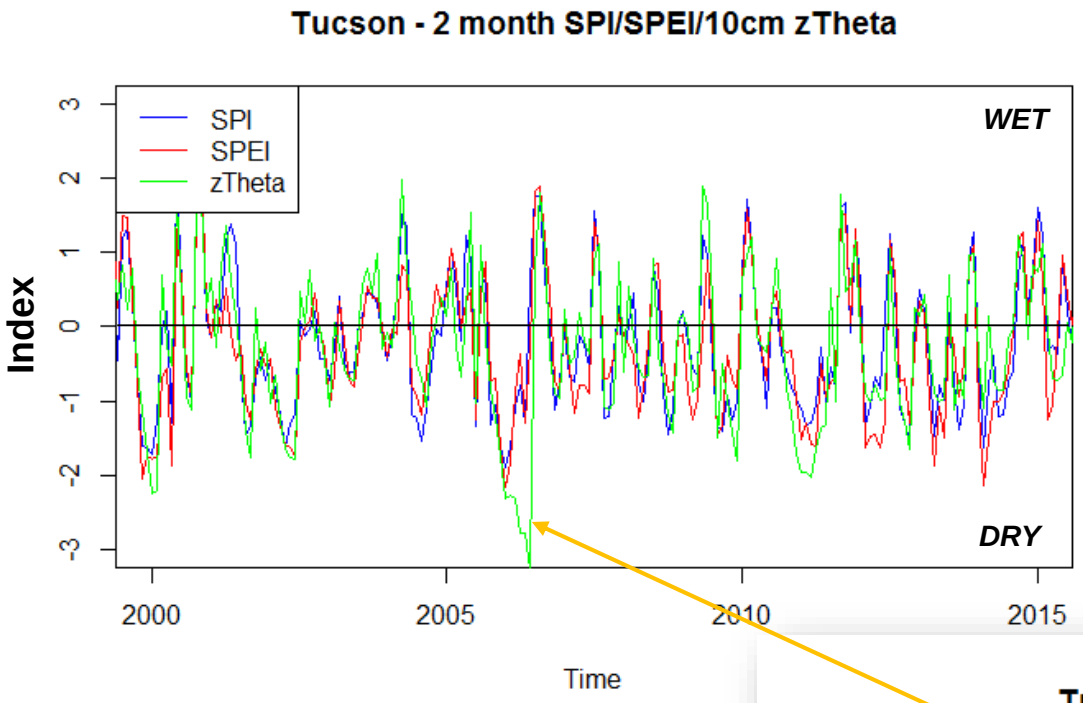
Drought Monitoring Playbook Prototype

Soils information from Ecological Site Descriptions

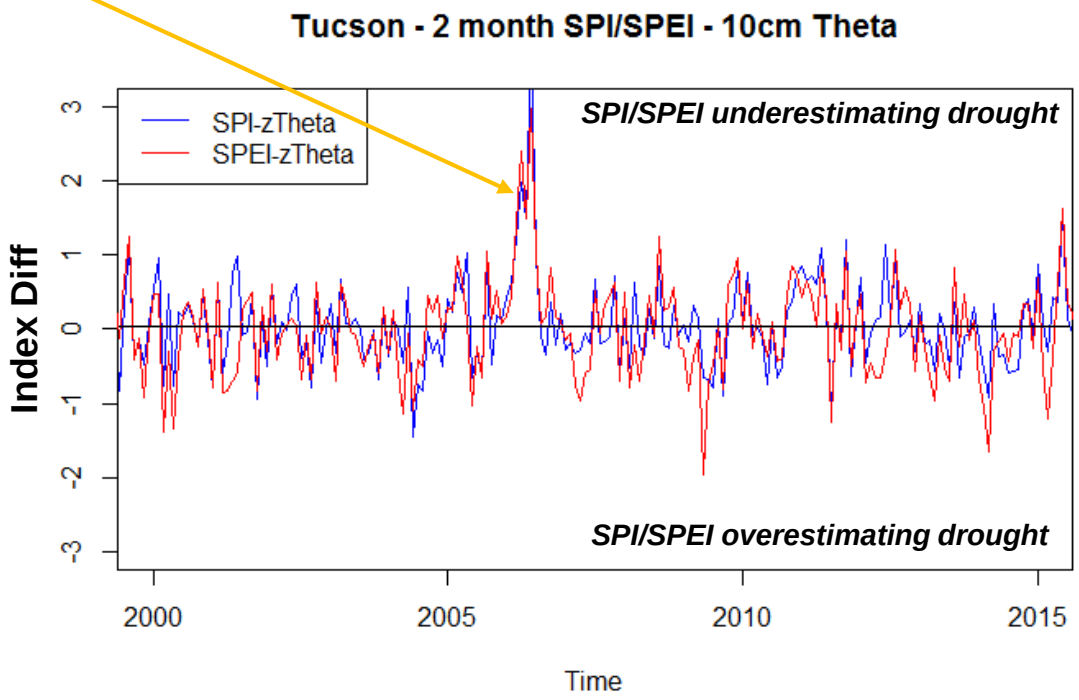
Ecological Site Description Information	
Site ID, Name	R040XA101AZ, Basalt Hills
Site Type	Rangeland
Vegetation	Foothill palo verde – saguaro/ white brittlebush – ocotillo/ bush muhly
Soil Description	Shallow soils formed on basic igneous parent material (Basalt) and related conglomerates



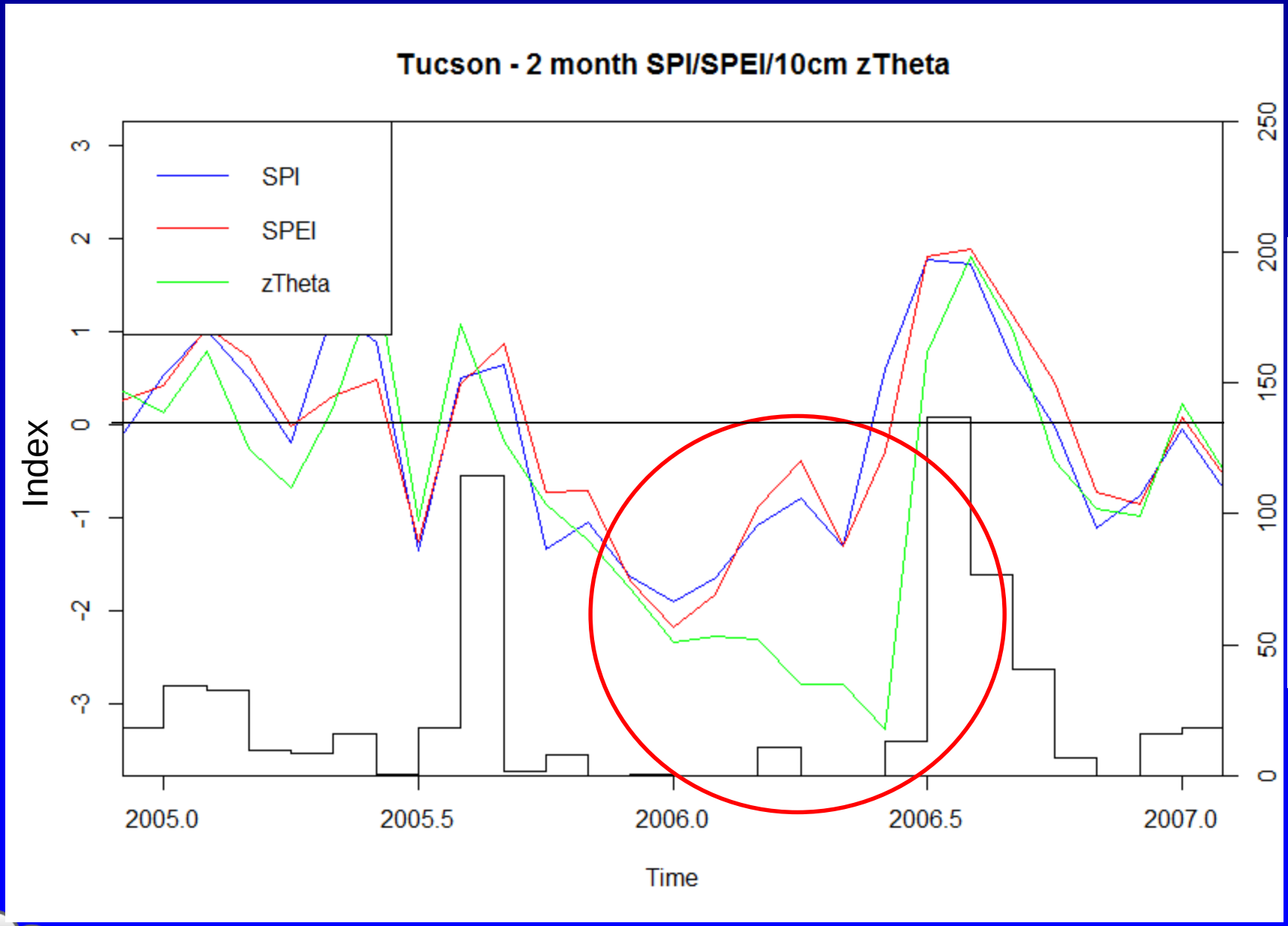




SPI ~ 10cm soil moisture r= 0.81
SPEI ~ 10cm soil moisture r= 0.76



CSAP
Climate Science Applications Program - University of Arizona


Tucson - 2 month SPI/SPEI/10cm zTheta
SPI
SPEI
zTheta
Index
3
2
1
0
-1
-2
-3
250
200
150
100
50
0
Monthly Total Precip (mm)
2005.0
2005.5
2006.0
2006.5
2007.0
Time

Preliminary take home

- Modeled shallow moisture (10cm) correlates highly with 2 month SPI (r~0.8) → 2 month SPI for shallow rooted vegetation impacts? Strength varies by month
- Correlations weaker at 30 and 50 cm (r~0.6) but still significant with longer timescales, ~6-24 months
- Correlations with SPEI (includes temperature) not consistently higher than SPI; ET estimation method matters (Hargreaves/P-M/Thornthwaite)
- Working to get Drought Playbook online as interactive tool later this year

Thanks!

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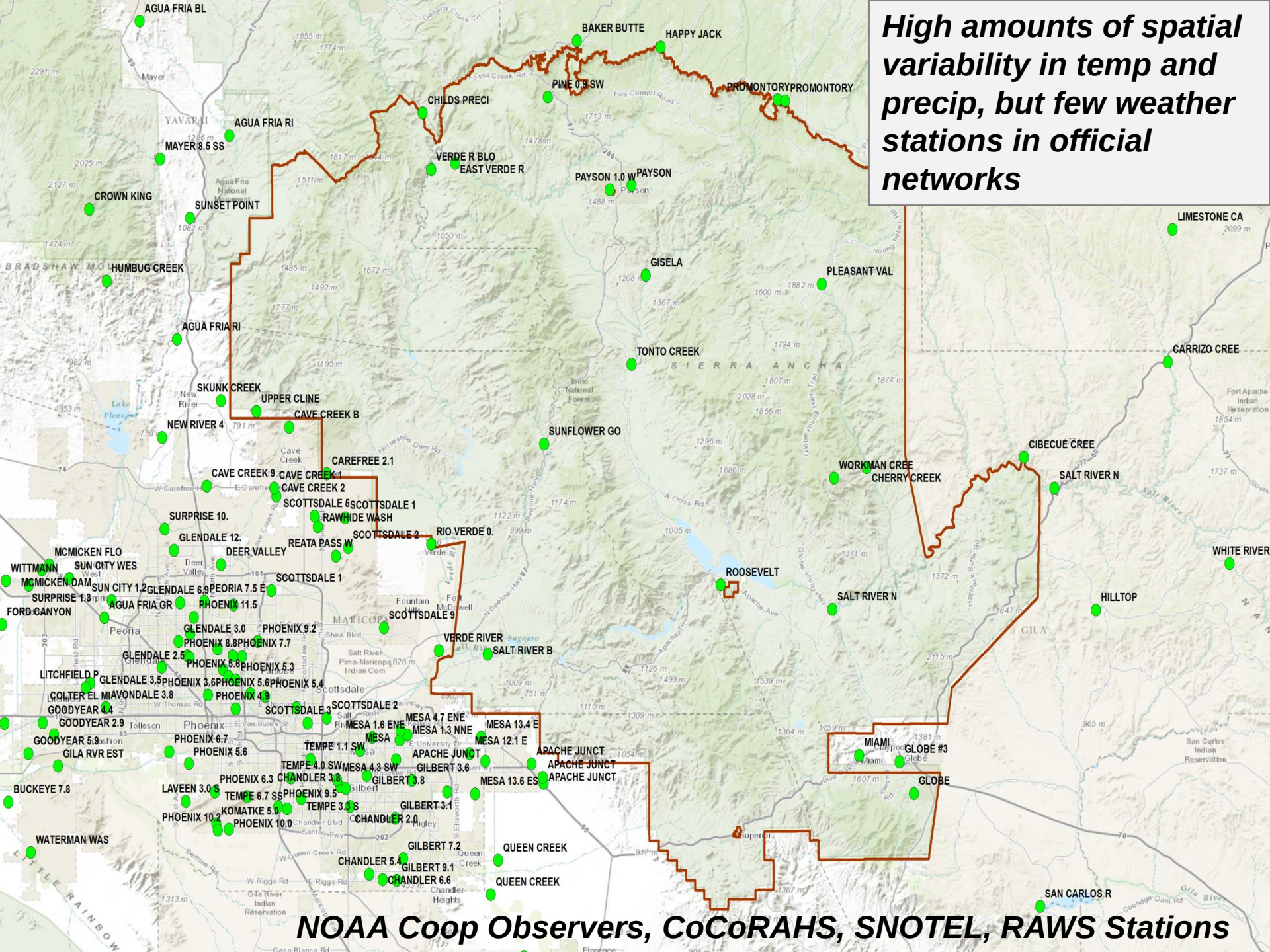
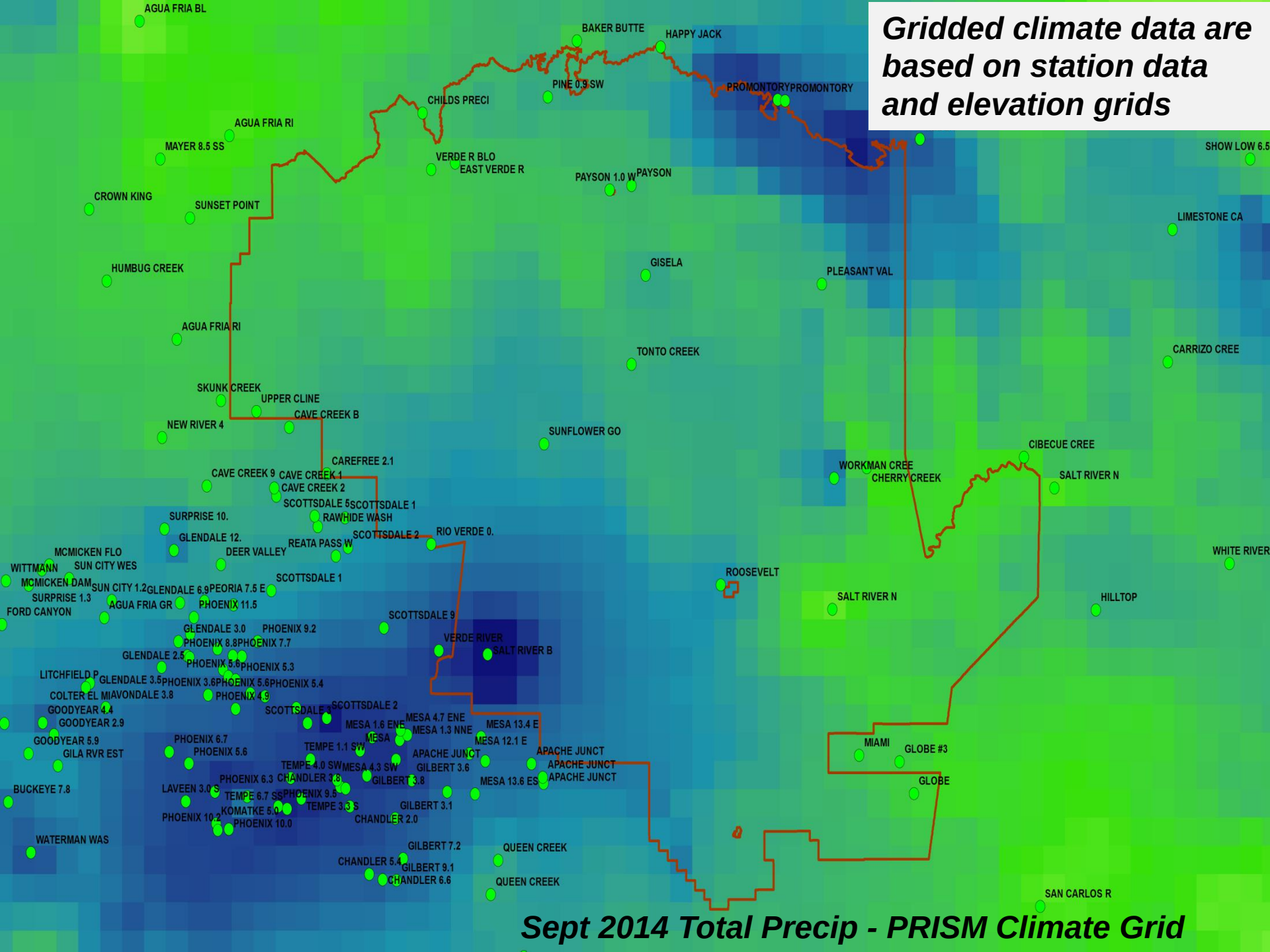
http://cals.arizona.edu/climate


High amounts of spatial variability in temp and precip, but few weather stations in official networks
AGUA FRIA BL
BAKER BUTTE
HAPPY JACK
PINE 0.9 SW
PROMONTORY
PROMONTORY
CHILDS PRECI
AGUA FRIA RI
MAYER 8.5 SS
VERDE R BLO
EAST VERDE R
PAYSON 1.0 W
PAYSON
CROWN KING
SUNSET POINT
LIMESTONE CA
GISELA
PLEASANT VAL
HUMBUG CREEK
AGUA FRIA RI
TONTO CREEK
CARRIZO CREE
SKUNK CREEK
UPPER CLINE
CAVE CREEK B
NEW RIVER 4
SUNFLOWER GO
CIBECUE CREE
WORKMAN CREE
CHERRY CREEK
SALT RIVER N
CAREFREE 2.1
CAVE CREEK 9
CAVE CREEK 1
CAVE CREEK 2
SCOTTSDALE 5
SCOTTSDALE 1
RAWHIDE WASH
SURPRISE 10.
SCOTTSDALE 2
RIO VERDE 0.
GLENDALE 12.
REATA PASS W
DEER VALLEY
WHITE RIVER
MCMICKEN FLO
SUN CITY WES
WITTMANN
SCOTTSDALE 1
ROOSEVELT
MCMICKEN DAM
SUN CITY 1.2
GLENDALE 6.9
PEORIA 7.5 E
SURPRISE 1.3
AGUA FRIA GR
PHOENIX 11.5
SALT RIVER N
HILLTOP
FORD CANYON
SCOTTSDALE 9
GLENDALE 3.0
PHOENIX 9.2
VERDE RIVER
PHOENIX 8.8
PHOENIX 7.7
SALT RIVER B
GLENDALE 2.5
PHOENIX 5.6
PHOENIX 5.3
LITCHFIELD P
GLENDALE 3.5
PHOENIX 3.6
PHOENIX 5.6
PHOENIX 5.4
COLTER EL MIA
VONDALE 3.8
PHOENIX 4.9
SCOTTSDALE 2
GOODYEAR 4.4
SCOTTSDALE 3
MESA 4.7 ENE
MESA 1.6 ENE
MESA 1.3 NNE
MESA 13.4 E
GOODYEAR 2.9
MESA
MESA 12.1 E
MIAMI
GLOBE #3
GOODYEAR 5.9
PHOENIX 6.7
TEMPE 1.1 SW
APACHE JUNCT
APACHE JUNCT
GILA RVR EST
PHOENIX 5.6
TEMPE 4.0 SW
MESA 4.3 SW
GILBERT 3.6
APACHE JUNCT
PHOENIX 6.3
CHANDLER 3.8
GILBERT 3.8
MESA 13.6 ES
APACHE JUNCT
GLOBE
BUCKEYE 7.8
LAVEEN 3.0 S
TEMPE 6.7 SS
PHOENIX 9.5
KOMATKE 5.0
TEMPE 3.3 S
GILBERT 3.1
PHOENIX 10.2
PHOENIX 10.0
CHANDLER 2.0
WATERMAN WAS
GILBERT 7.2
QUEEN CREEK
CHANDLER 5.4
GILBERT 9.1
CHANDLER 6.6
QUEEN CREEK
SAN CARLOS R
NOAA Coop Observers, CoCoRAHS, SNOTEL, RAWS Stations


Gridded climate data are based on station data and elevation grids
AGUA FRIA BL
BAKER BUTTE
HAPPY JACK
PINE 0.9 SW
PROMONTORY
PROMONTORY
CHILDS PRECI
AGUA FRIA RI
MAYER 8.5 SS
VERDE R BLO
EAST VERDE R
PAYSON 1.0 W
PAYSON
SHOW LOW 6.5
CROWN KING
SUNSET POINT
LIMESTONE CA
HUMBUG CREEK
GISELA
PLEASANT VAL
AGUA FRIA RI
TONTO CREEK
CARRIZO CREE
SKUNK CREEK
UPPER CLINE
CAVE CREEK B
NEW RIVER 4
SUNFLOWER GO
CIBECUE CREE
CAREFREE 2.1
WORKMAN CREE
CHERRY CREEK
SALT RIVER N
CAVE CREEK 9
CAVE CREEK 1
CAVE CREEK 2
SCOTTSDALE 5
SCOTTSDALE 1
SURPRISE 10.
RAWHIDE WASH
GLENDALE 12.
SCOTTSDALE 2
RIO VERDE 0.
REATA PASS W
MCMICKEN FLO
DEER VALLEY
WHITE RIVER
WITTMANN
SUN CITY WES
ROOSEVELT
MCMICKEN DAM
SUN CITY 1.2
GLENDALE 6.9
PEORIA 7.5 E
SCOTTSDALE 1
SURPRISE 1.3
AGUA FRIA GR
PHOENIX 11.5
SALT RIVER N
HILLTOP
FORD CANYON
SCOTTSDALE 9
GLENDALE 3.0
PHOENIX 9.2
VERDE RIVER
PHOENIX 8.8
PHOENIX 7.7
SALT RIVER B
GLENDALE 2.5
PHOENIX 5.6
PHOENIX 5.3
LITCHFIELD P
GLENDALE 3.5
PHOENIX 3.6
PHOENIX 5.6
PHOENIX 5.4
COLTER EL MI
AVONDALE 3.8
PHOENIX 4.9
SCOTTSDALE 2
GOODYEAR 4.4
SCOTTSDALE 3
MESA 4.7 ENE
GOODYEAR 2.9
MESA 1.6 ENE
MESA 1.3 NNE
MESA 13.4 E
GOODYEAR 5.9
PHOENIX 6.7
MESA
MESA 12.1 E
MIAMI
GLOBE #3
GILA RVR EST
PHOENIX 5.6
TEMPE 1.1 SW
APACHE JUNCT
APACHE JUNCT
TEMPE 4.0 SW
MESA 4.3 SW
GILBERT 3.6
APACHE JUNCT
PHOENIX 6.3
CHANDLER 3.8
GILBERT 3.8
MESA 13.6 ES
GLOBE
BUCKEYE 7.8
LAVEEN 3.0 S
TEMPE 6.7 SS
PHOENIX 9.5
KOMATKE 5.0
TEMPE 3.3 S
GILBERT 3.1
PHOENIX 10.2
PHOENIX 10.0
CHANDLER 2.0
WATERMAN WAS
GILBERT 7.2
QUEEN CREEK
CHANDLER 5.4
GILBERT 9.1
CHANDLER 6.6
QUEEN CREEK
SAN CARLOS R
Sept 2014 Total Precip - PRISM Climate Grid