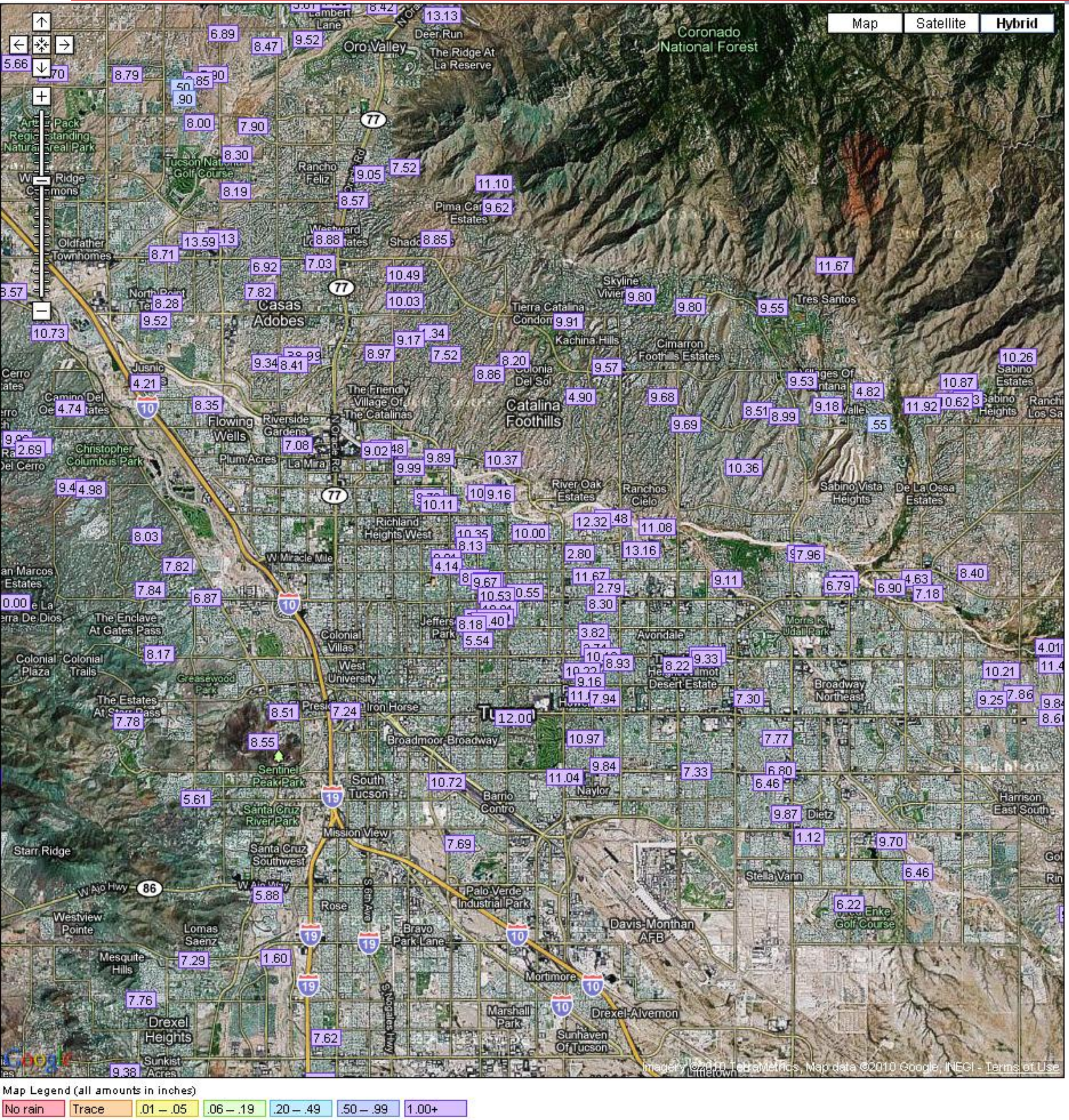
Drought, Fire & Monsoon:
Current Conditions, Forecasts, & Research Update

A UA Science Connections / CLIMAS Briefing

Introduction by Gary Woodard, UA Science Knowledge Transfer
Biosphere2, College of Science, University of Arizona

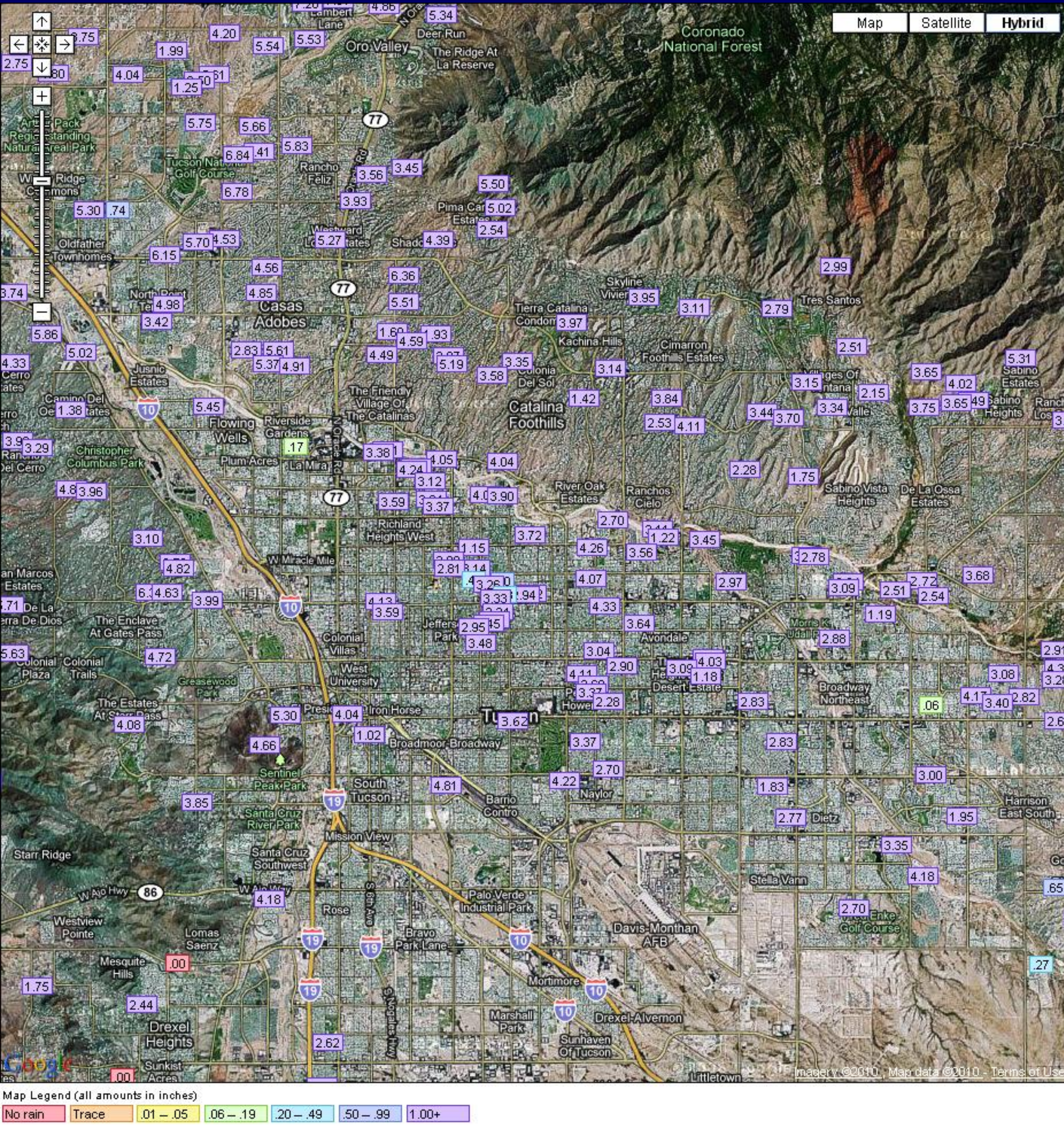
Flandrau Science Center, Galaxy Room
The University of Arizona
14 June 2012

2008 monsoon was very wet…



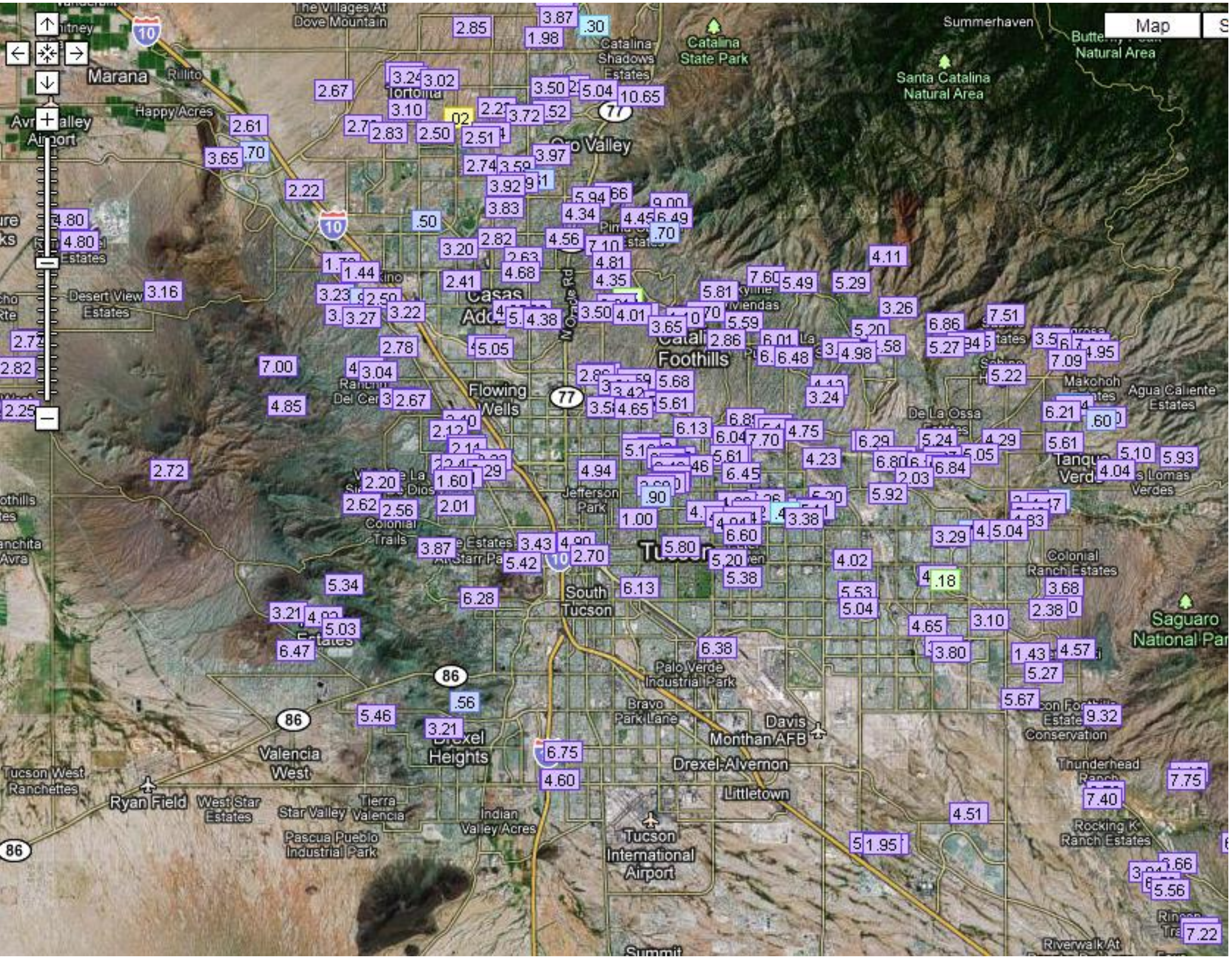
Median monsoonal rainfall was over 9”

2009 monsoon was very dry



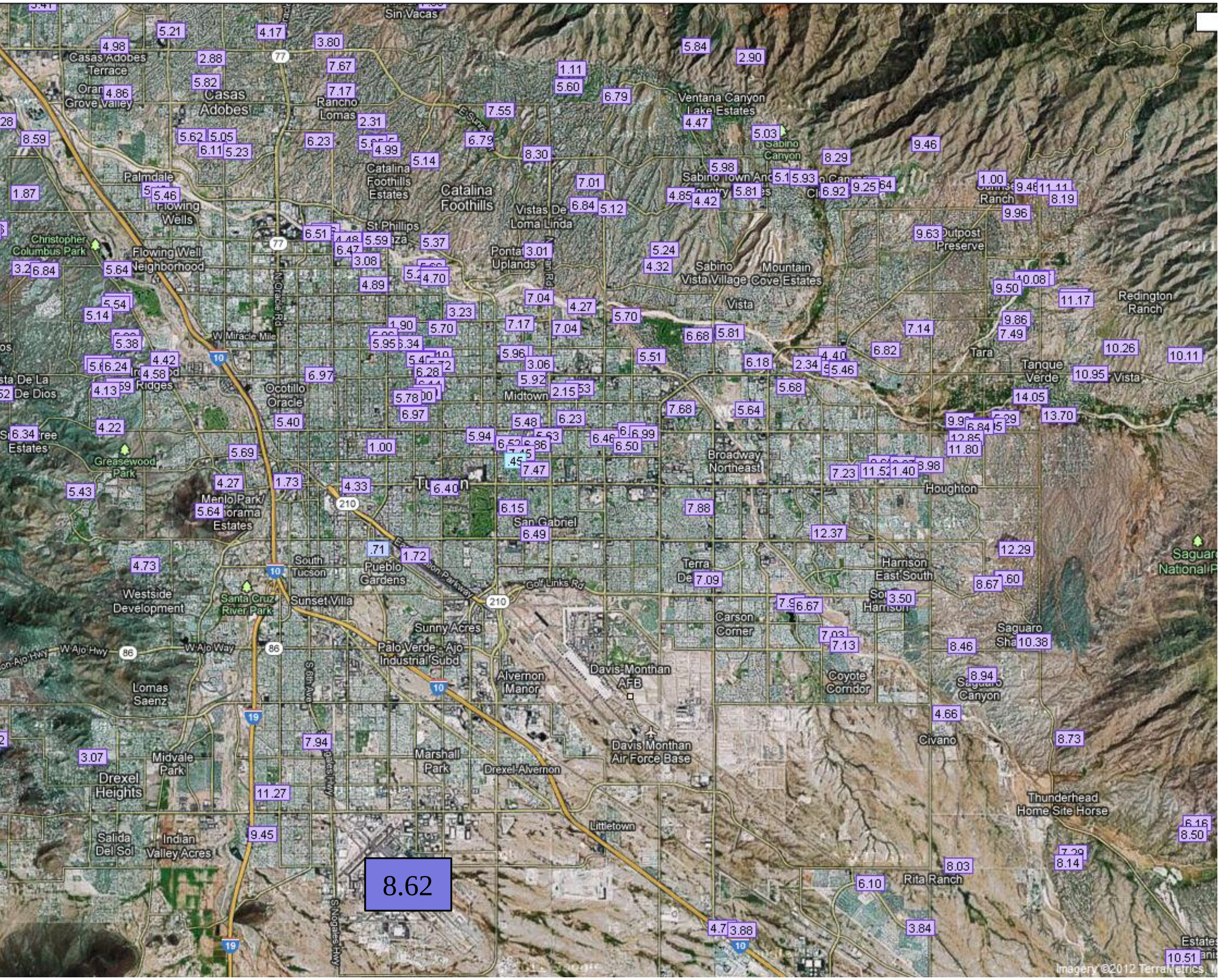
Median monsoonal rainfall was around 4”

2010 monsoon was fairly normal



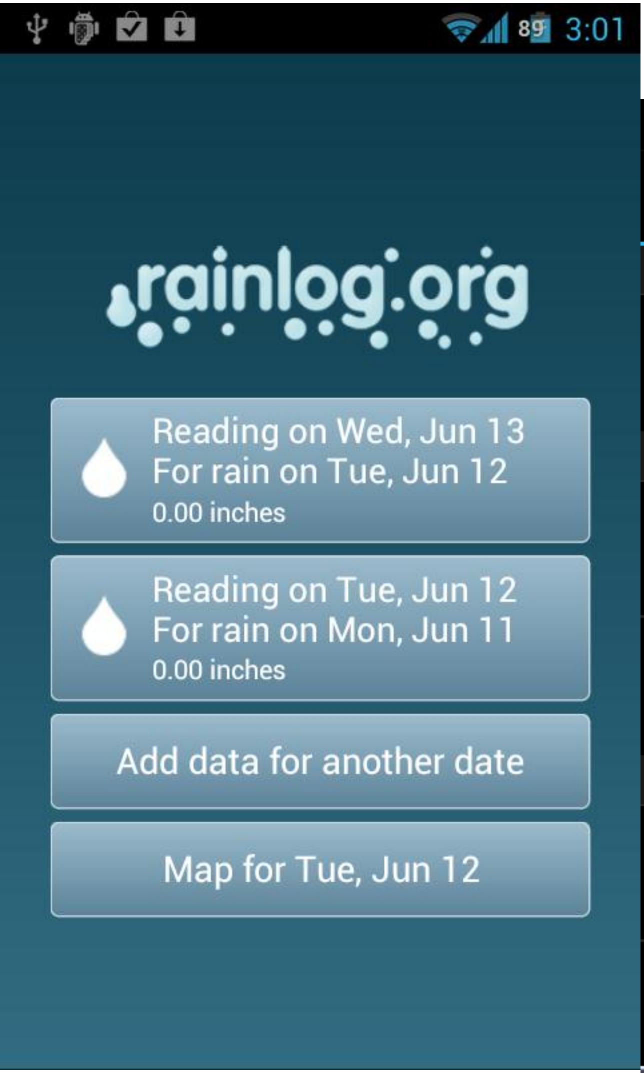
Median monsoonal rainfall was nearly 6”

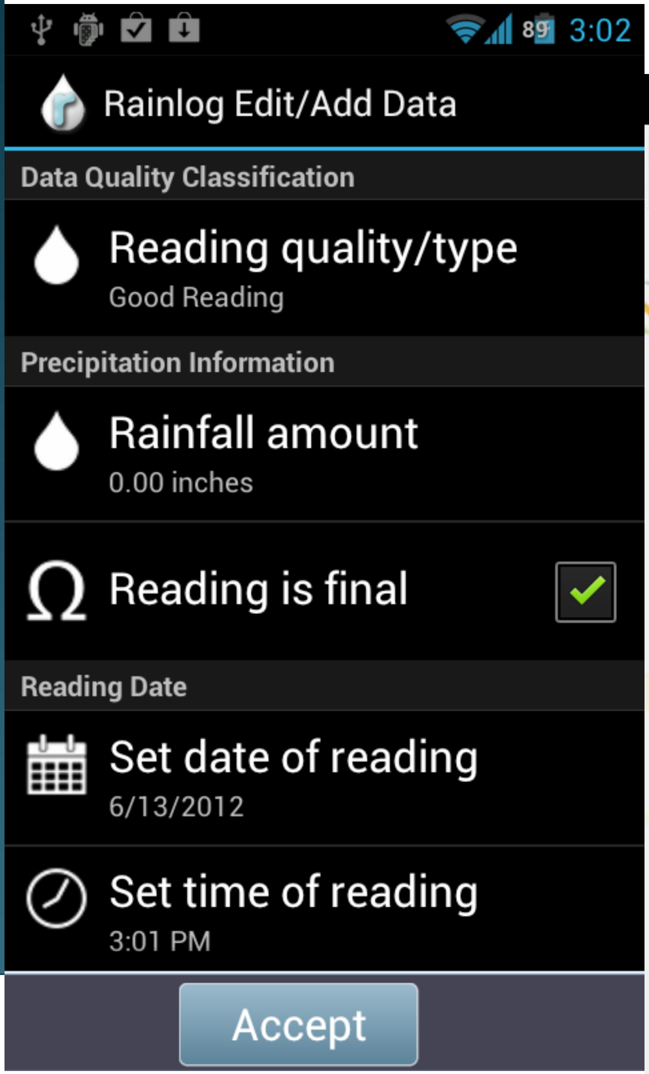
2011 monsoon was sneaky



Officially, the monsoon was 10^{th} wettest, with 8.62” at the airport… but skewed by localized 2.8” event on September 15.

RainLog now has smart phone apps





Today’s speakers & topics

Mike Crimmins, Soil, Water and Environmental Science
Current drought conditions and impacts

Don Falk, School of Natural Resources and Environment
Current fire conditions and trends

JJ Brost, Nat’l Weather Service, Tucson Forecast Office
2012 Monsoon Outlook

Dan Griffin, UA Laboratory of Tree-Ring Research
What tree-rings tell us about monsoon precipitation variability over past centuries

Trenton Franz, Hydrology and Water Resources,
Cosmic-ray soil moisture observing system (COSMOS)

Southwest Drought Update
June 2012

Mike Crimmins
Assoc. Professor/Extension Specialist
Dept. of Soil, Water, & Environmental Science &
Arizona Cooperative Extension
The University of Arizona

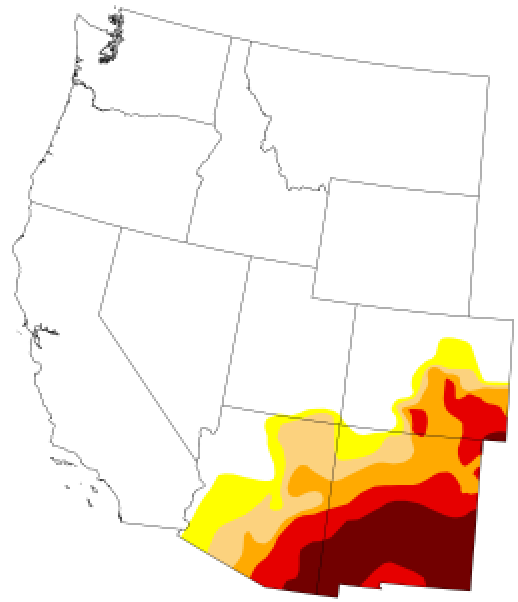
U.S. Drought Monitor

June 14, 2011
Valid 7 a.m. EST

West

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	78.53	21.47	17.94	14.04	9.85	5.22
Last Week (06/07/2011 map)	78.60	21.40	17.94	13.92	9.57	4.74
3 Months Ago (03/15/2011 map)	74.39	25.61	17.06	7.78	1.52	0.00
Start of Calendar Year (12/28/2010 map)	73.26	26.74	11.98	0.89	0.00	0.00
Start of Water Year (09/28/2010 map)	62.50	37.50	8.14	0.56	0.00	0.00
One Year Ago (06/08/2010 map)	68.88	31.12	13.38	3.39	0.00	0.00



Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://drought.unl.edu/dm

Released Thursday, June 16, 2011
Brian Fuchs, National Drought Mitigation Center

http://www.drought.unl.edu

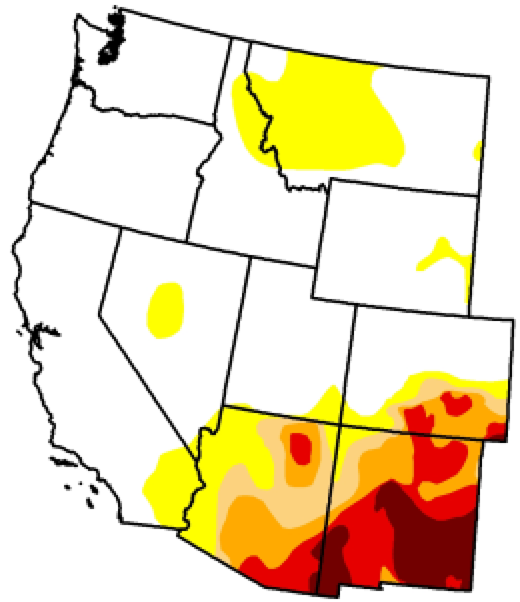
U.S. Drought Monitor

October 4, 2011
Valid 7 a.m. EST

West

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	66.39	33.61	19.04	14.99	9.30	3.90
Last Week (09/27/2011 map)	66.72	33.28	19.04	14.99	9.30	3.81
3 Months Ago (07/05/2011 map)	73.58	26.42	19.36	16.03	11.35	5.71
Start of Calendar Year (12/28/2010 map)	73.26	26.74	11.98	0.89	0.00	0.00
Start of Water Year (09/27/2011 map)	66.72	33.28	19.04	14.99	9.30	3.81
One Year Ago (09/28/2010 map)	62.50	37.50	8.14	0.56	0.00	0.00



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http://droughtmonitor.unl.edu

Released Thursday, October 6, 2011

http://www.drought.unl.edu

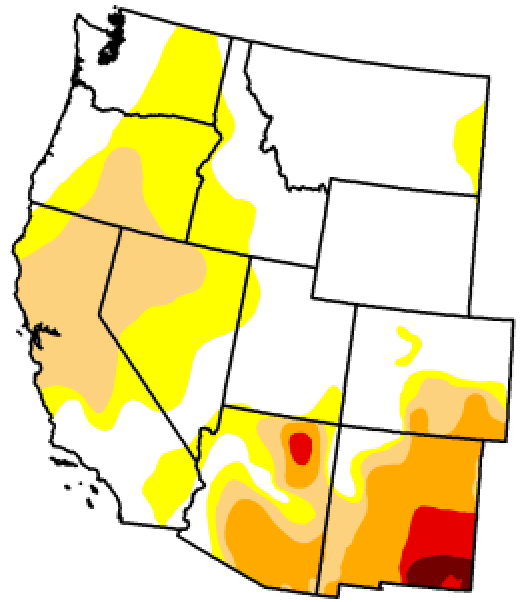
U.S. Drought Monitor

January 3, 2012
Valid 7 a.m. EST

West

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	50.20	49.80	28.05	11.84	2.67	0.78
Last Week (12/27/2011 map)	48.49	51.51	20.05	12.22	2.67	0.78
3 Months Ago (10/04/2011 map)	66.39	33.61	19.04	14.99	9.30	3.90
Start of Calendar Year (12/27/2011 map)	48.49	51.51	20.05	12.22	2.67	0.78
Start of Water Year (09/27/2011 map)	66.72	33.28	19.04	14.99	9.30	3.81
One Year Ago (12/28/2010 map)	73.26	26.74	11.98	0.89	0.00	0.00



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The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu

Released Thursday, January 5, 2012
Brad Rippey, U.S. Department of Agriculture

http://www.drought.unl.edu

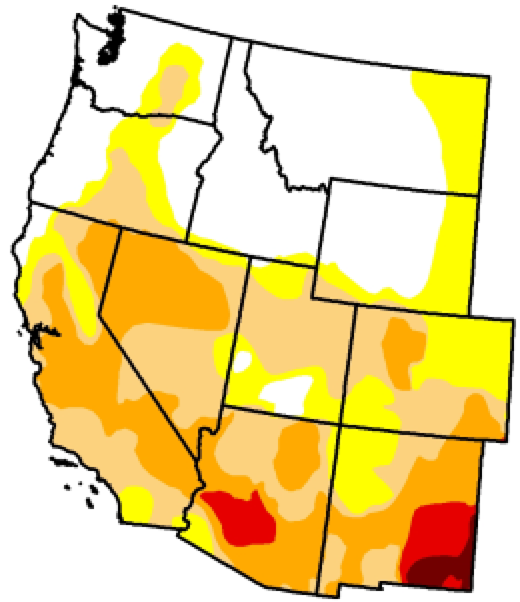
U.S. Drought Monitor

April 3, 2012
Valid 7 a.m. EST

West

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	31.44	68.56	48.66	24.84	3.78	0.93
Last Week (03/27/2012 map)	35.56	64.44	47.91	23.86	3.78	0.94
3 Months Ago (01/03/2012 map)	50.20	49.80	28.05	11.84	2.67	0.78
Start of Calendar Year (12/27/2011 map)	48.49	51.51	20.05	12.22	2.67	0.78
Start of Water Year (09/27/2011 map)	66.72	33.28	19.04	14.99	9.30	3.81
One Year Ago (03/29/2011 map)	76.08	23.92	18.56	13.12	2.12	0.00



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http://droughtmonitor.unl.edu

Released Thursday, April 5, 2012
Brian Fuchs, National Drought Mitigation Center

http://www.drought.unl.edu

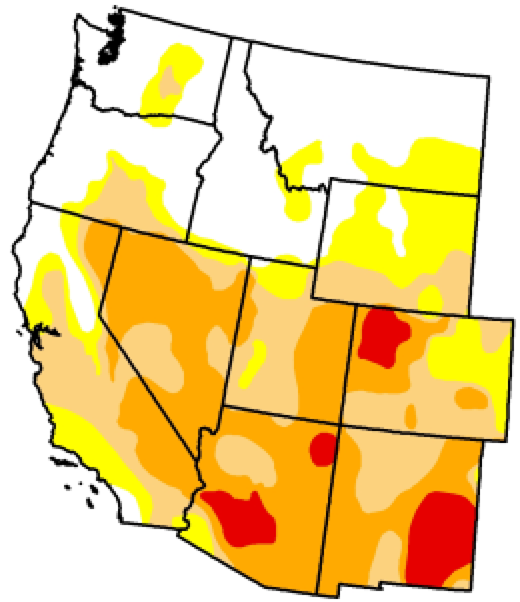
U.S. Drought Monitor

June 5, 2012
Valid 7 a.m. EST

West

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	29.60	70.40	53.30	31.03	4.95	0.00
Last Week (05/29/2012 map)	29.34	70.66	53.34	31.06	4.86	0.00
3 Months Ago (03/06/2012 map)	31.74	68.26	46.48	18.37	2.57	0.94
Start of Calendar Year (12/27/2011 map)	48.49	51.51	20.05	12.22	2.67	0.78
Start of Water Year (09/27/2011 map)	66.72	33.28	19.04	14.99	9.30	3.81
One Year Ago (05/31/2011 map)	78.60	21.40	17.94	13.92	9.02	3.36



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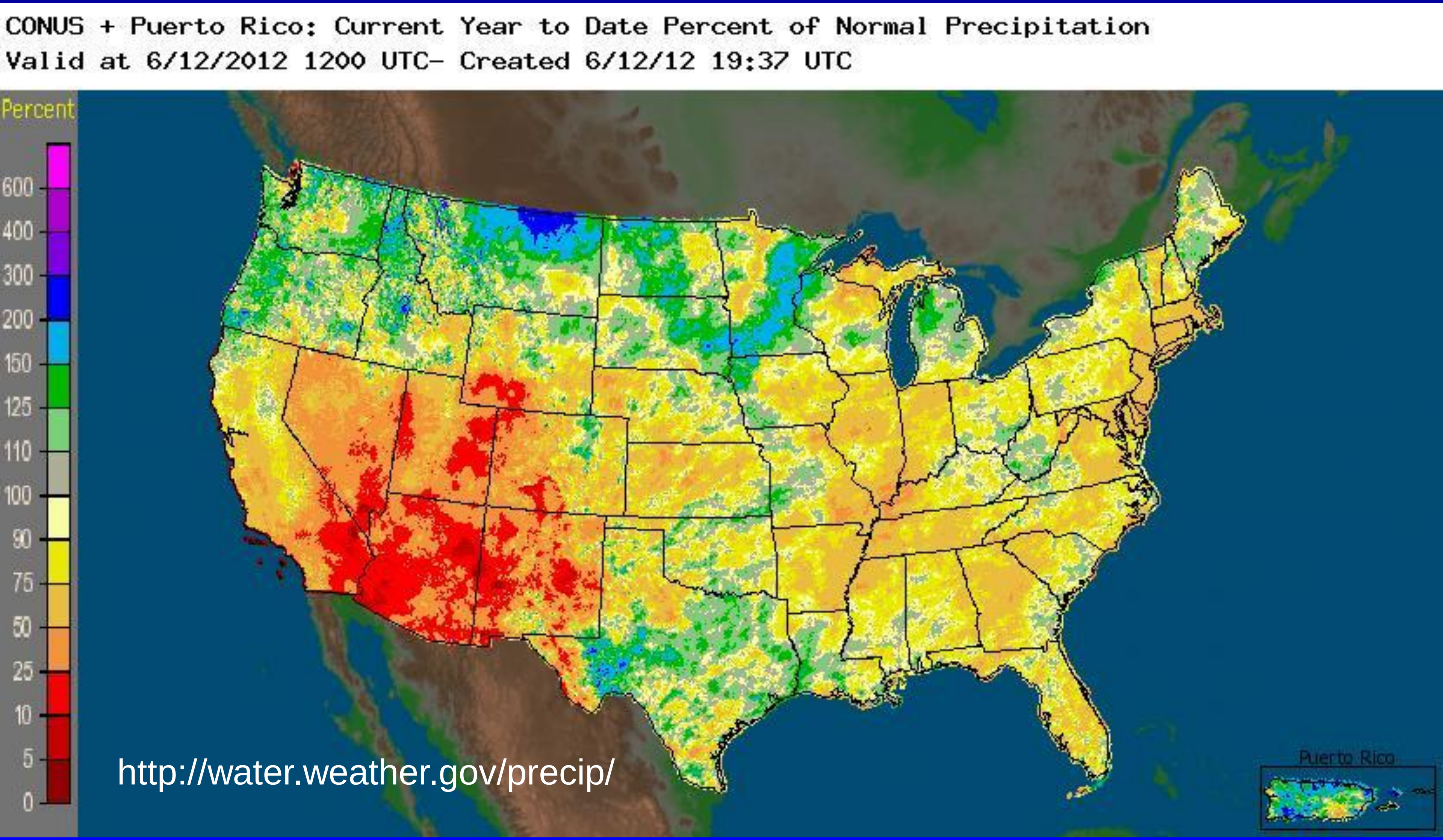
- D4 Drought - Exceptional

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

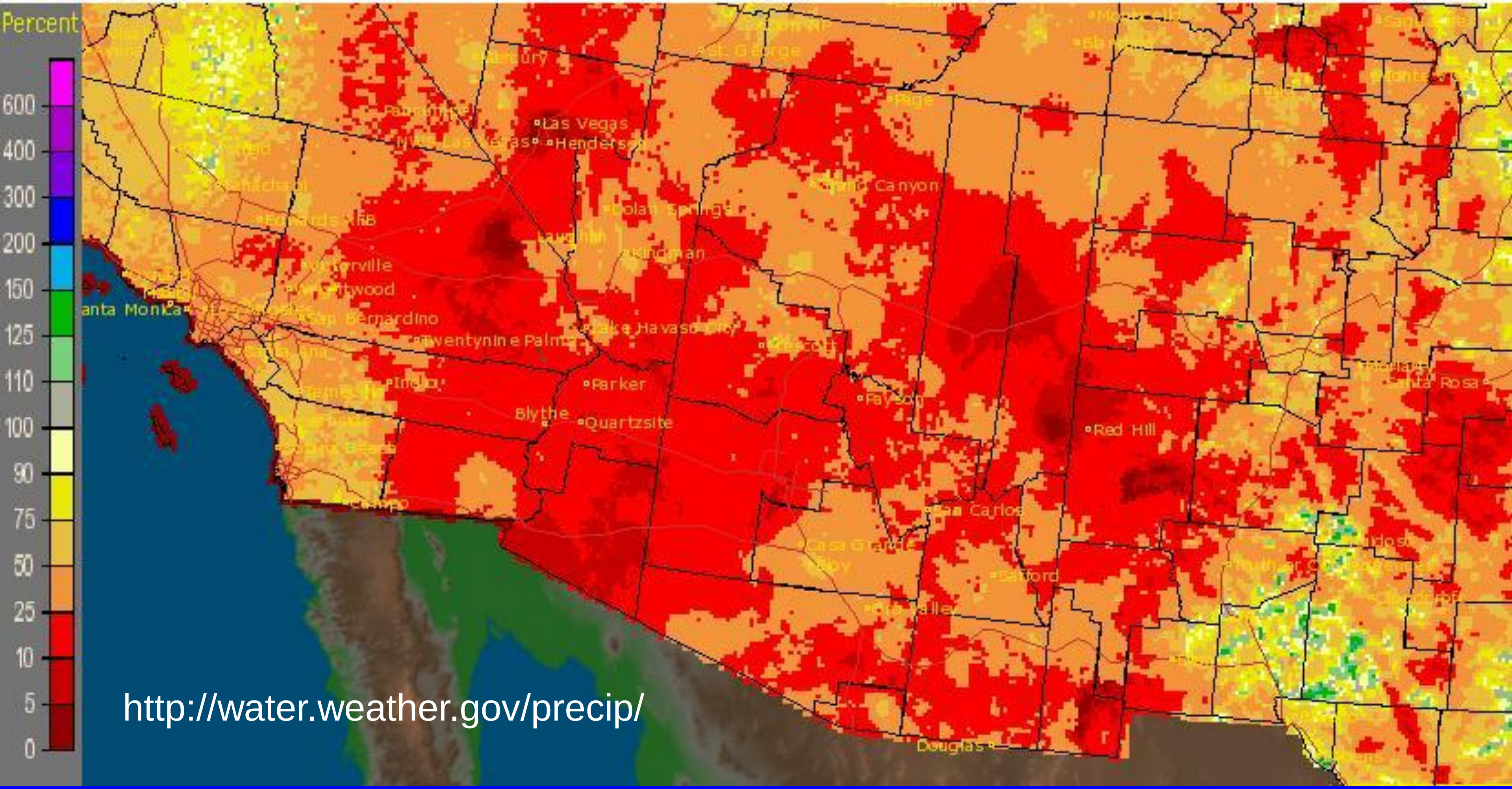
http://droughtmonitor.unl.edu

Released Thursday, June 7, 2012
National Drought Mitigation Center,

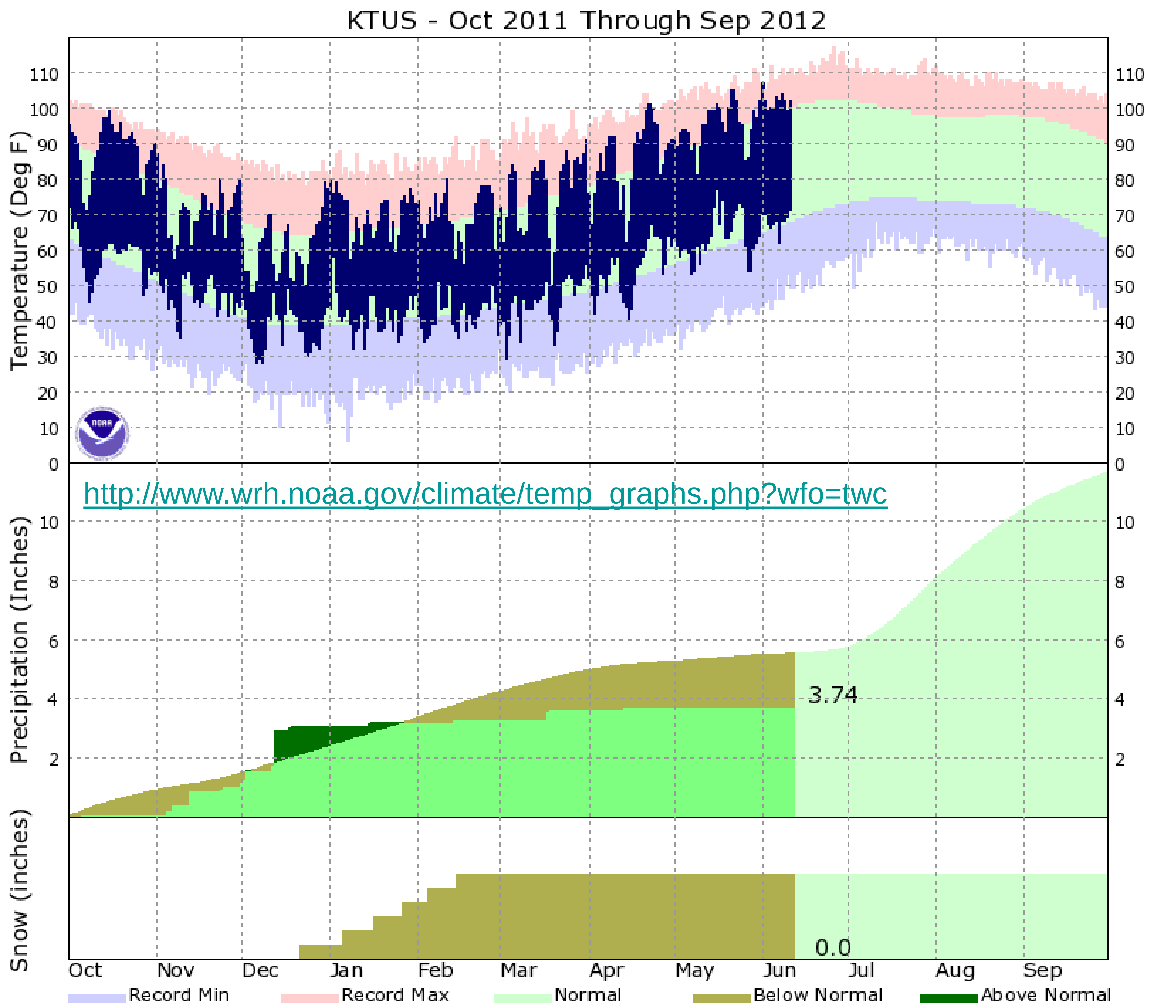
http://www.drought.unl.edu


CONUS + Puerto Rico: Current Year to Date Percent of Normal Precipitation
Valid at 6/12/2012 1200 UTC- Created 6/12/12 19:37 UTC
Percent
600
400
300
200
150
125
110
100
90
75
50
25
10
5
0
Puerto Rico
http://water.weather.gov/precip/

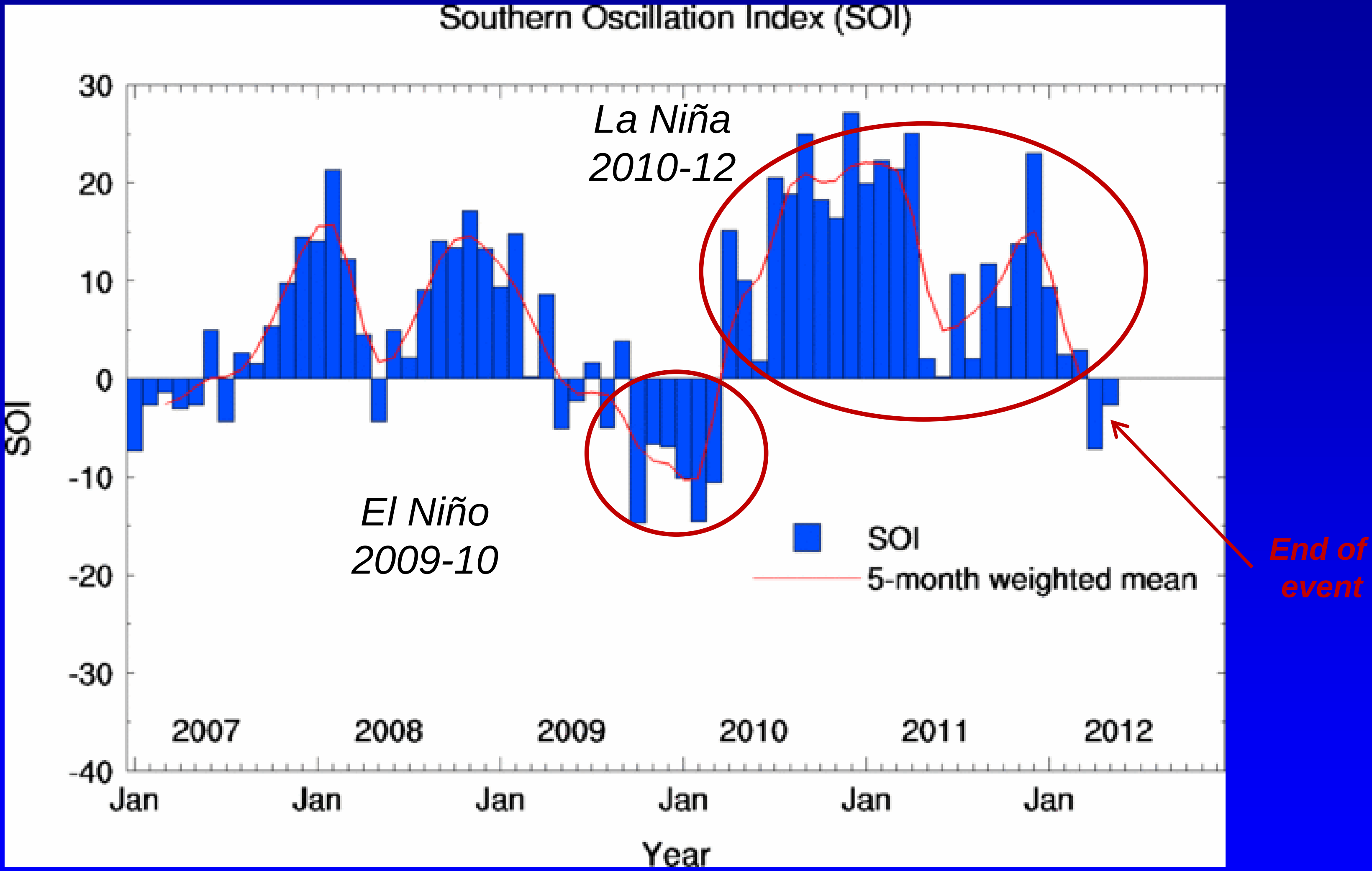
Arizona: Current Year to Date Percent of Normal Precipitation
Valid at 6/12/2012 1200 UTC- Created 6/12/12 19:49 UTC



http://water.weather.gov/precip/

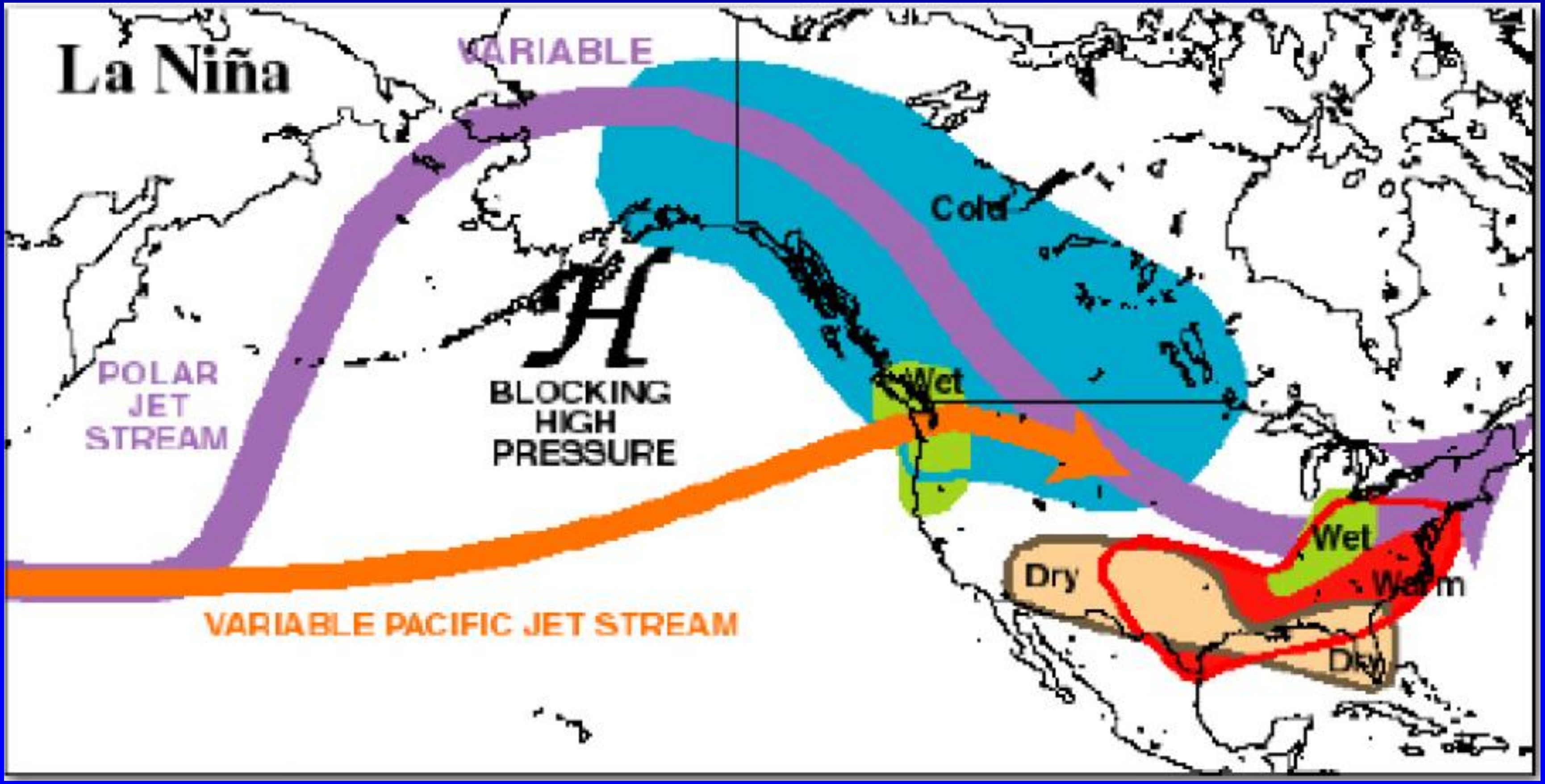

KTUS - Oct 2011 Through Sep 2012
Temperature (Deg F)
Precipitation (Inches)
Snow (inches)
http://www.wrh.noaa.gov/climate/temp_graphs.php?wfo=twc
3.74
0.0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Record Min
Record Max
Normal
Below Normal
Above Normal

Double La Niña 2010-12



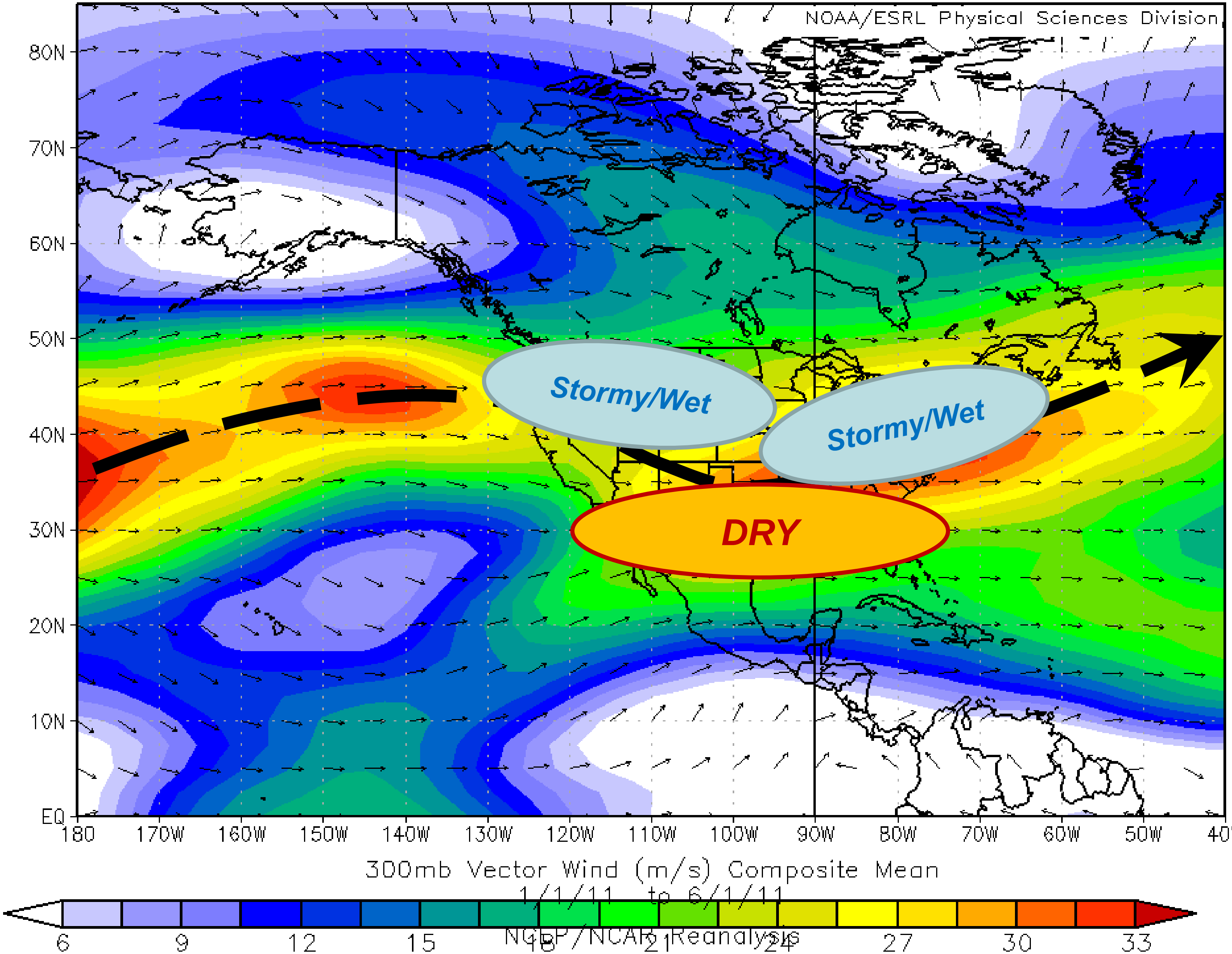
http://www.bom.gov.au/climate/current/soi2.shtml

Typical La Niña Jet Stream Pattern



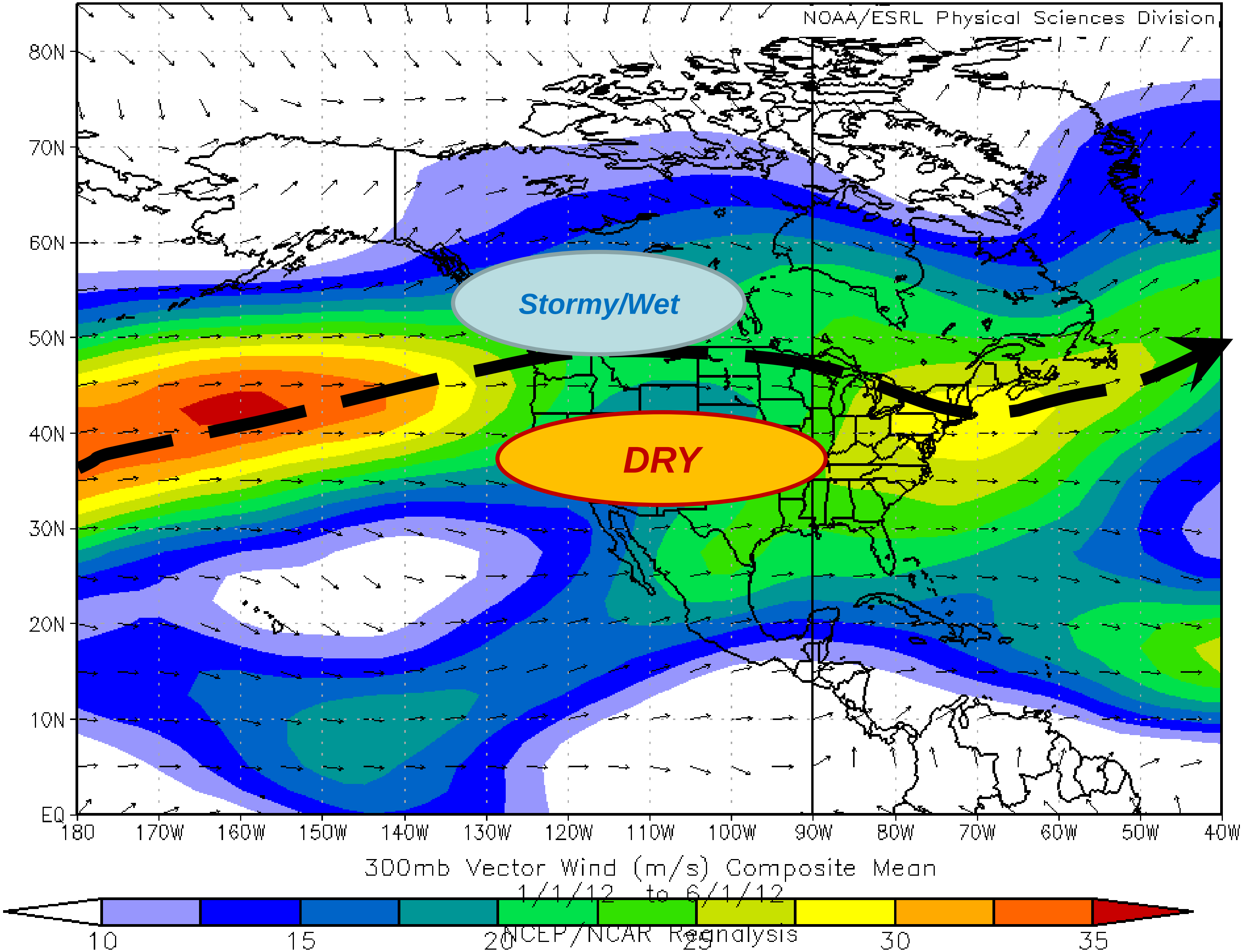
NOAA

Mean Jet Stream Pattern: Jan 1-June 1, 2011

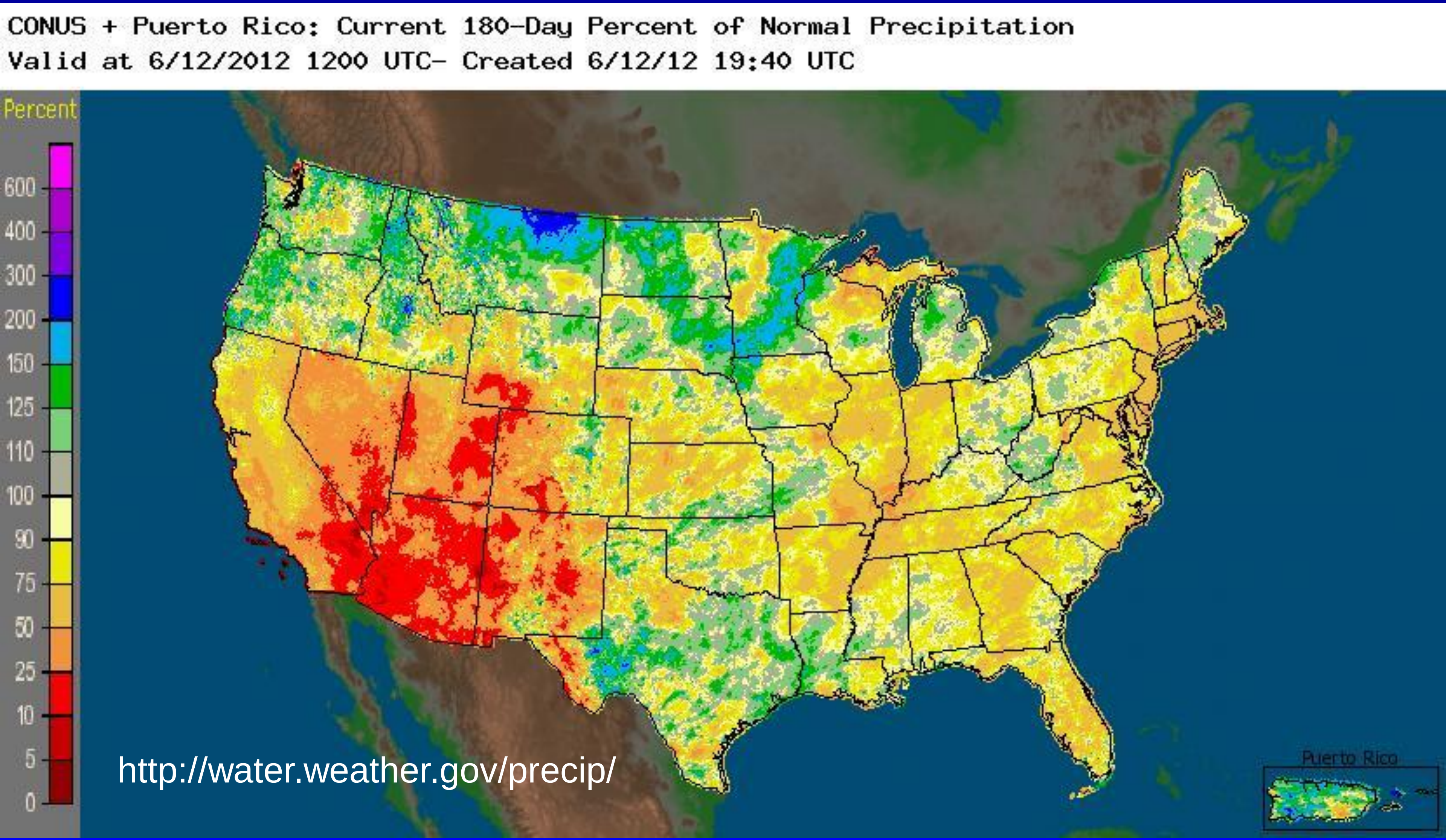


http://www.esrl.noaa.gov/psd/data/composites/day/

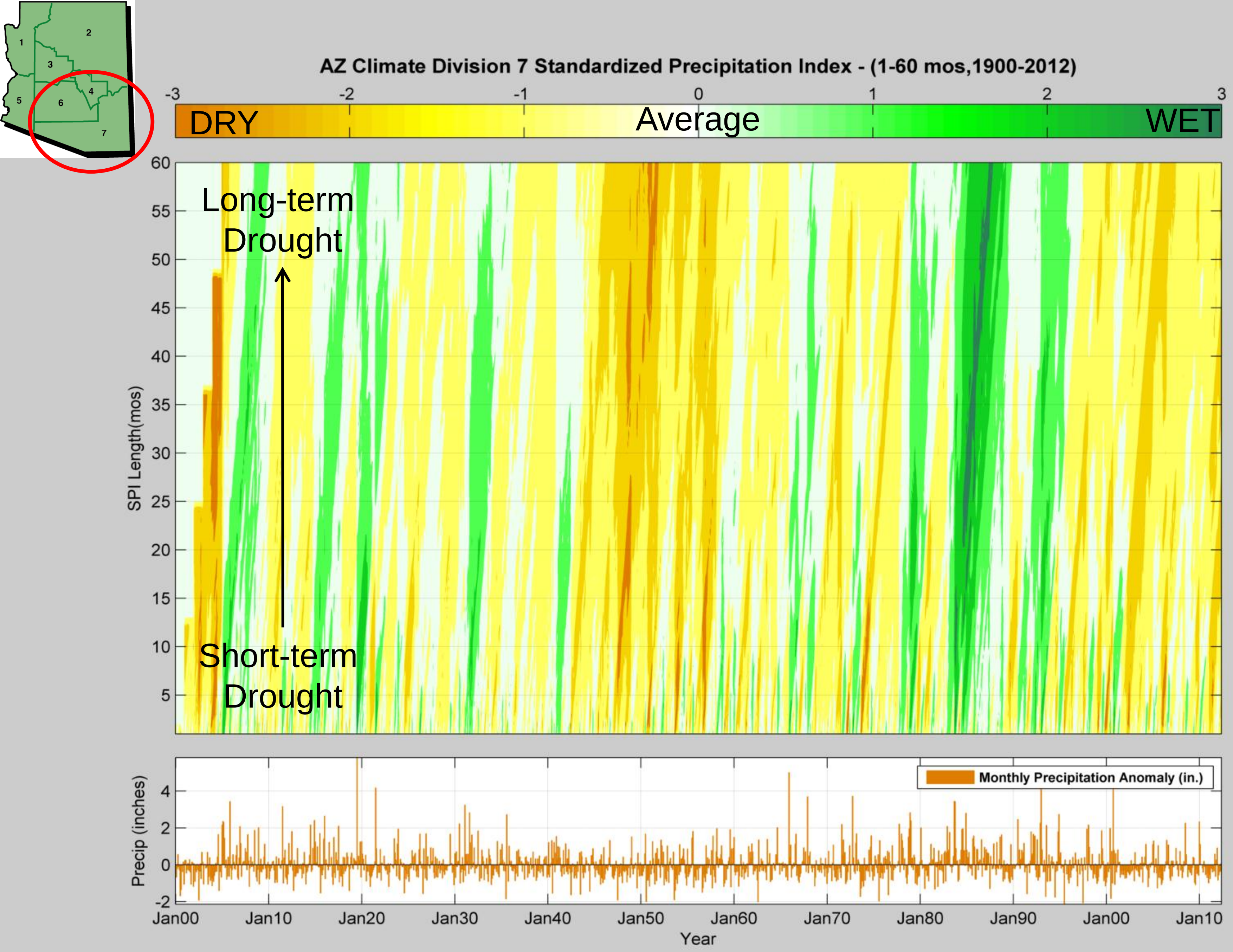
Mean Jet Stream Pattern: Jan 1-June 1, 2012



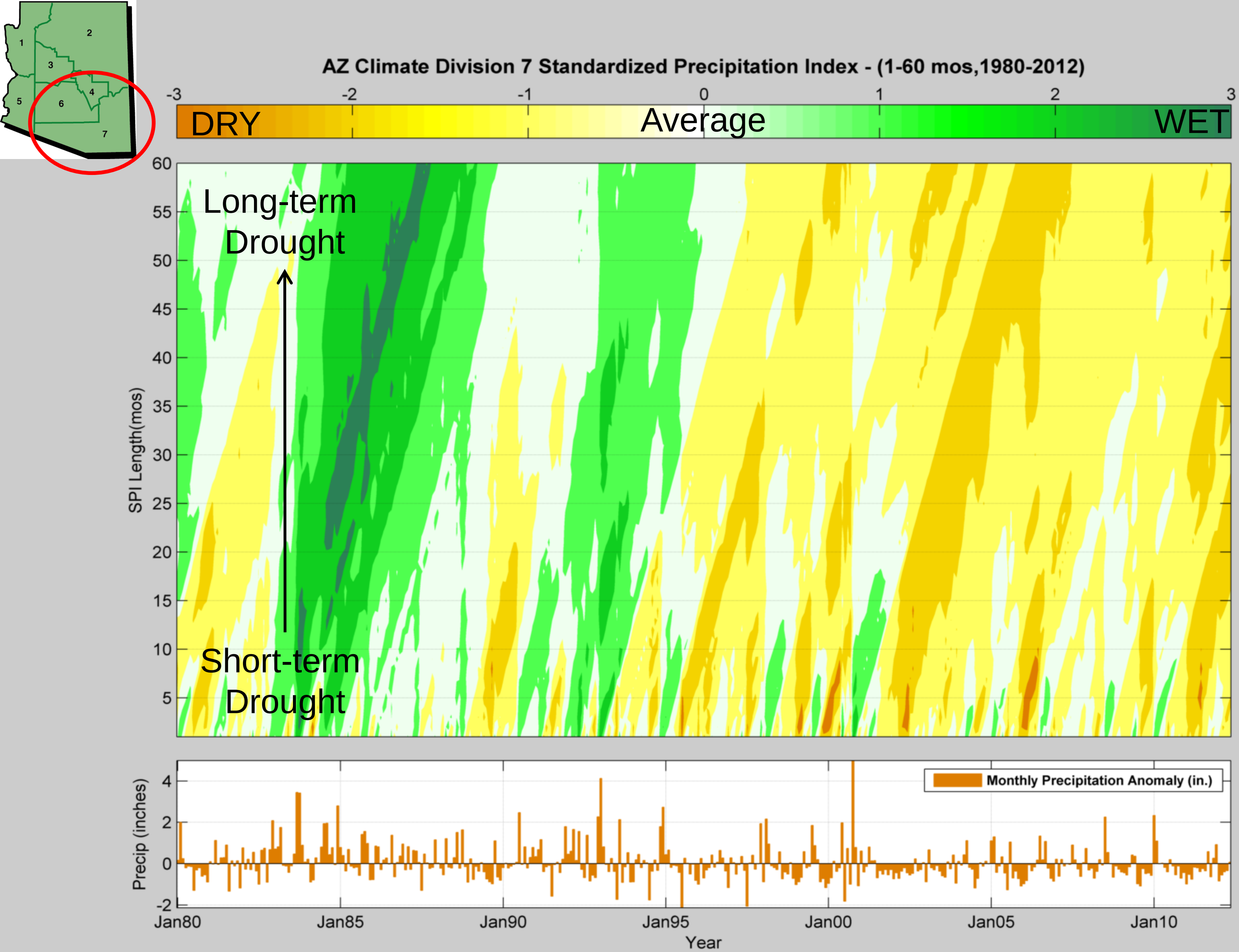
http://www.esrl.noaa.gov/psd/data/composites/day/



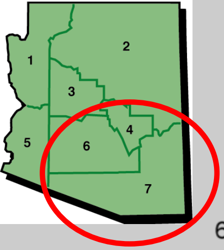
http://water.weather.gov/precip/



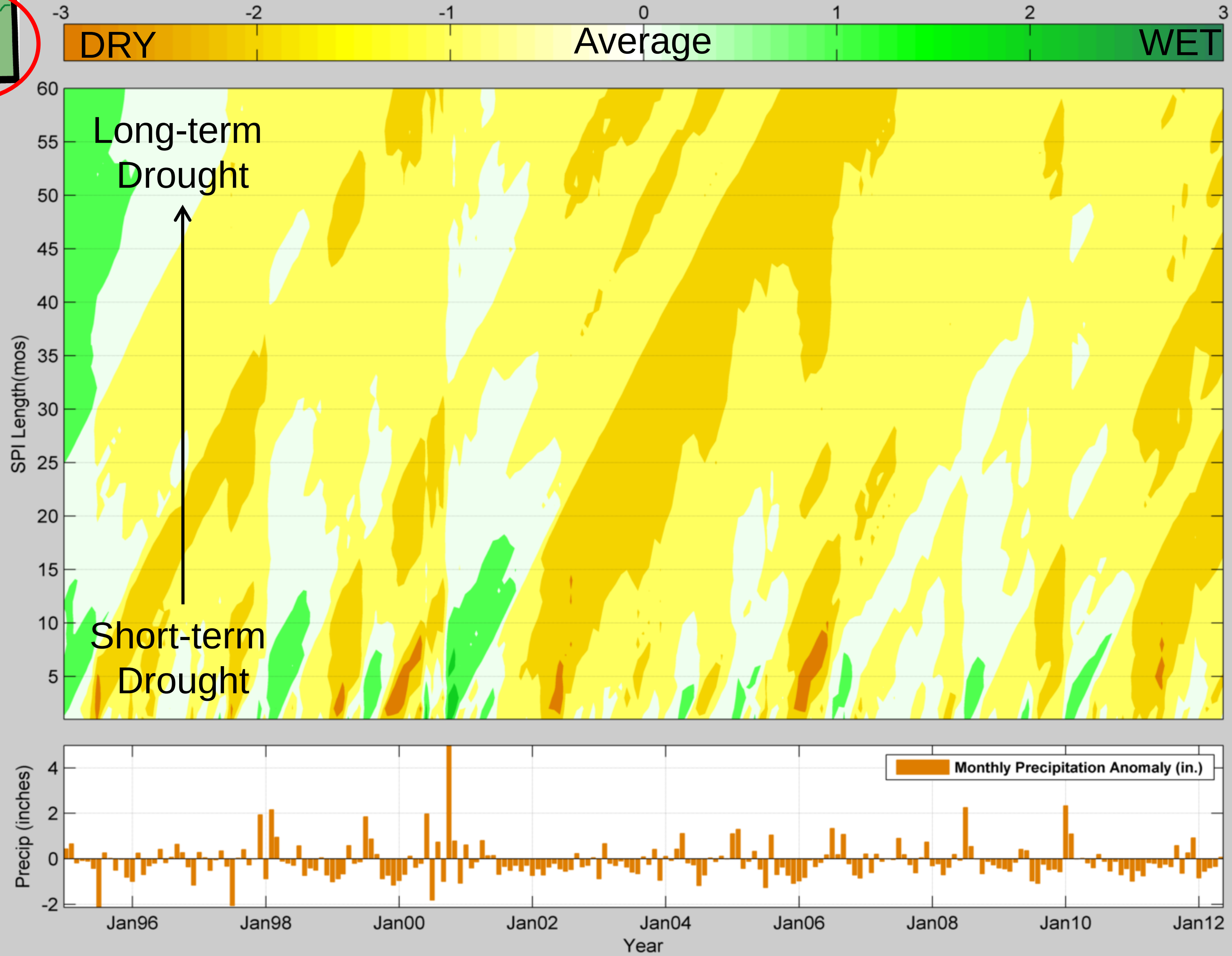
1
2
3
4
5
6
7
AZ Climate Division 7 Standardized Precipitation Index - (1-60 mos,1900-2012)
-3
-2
-1
0
1
2
3
DRY
Average
WET
Long-term Drought
Short-term Drought
SPI Length(mos)
Monthly Precipitation Anomaly (in.)
Precip (inches)
Jan00
Jan10
Jan20
Jan30
Jan40
Jan50
Jan60
Jan70
Jan80
Jan90
Jan00
Jan10
Year

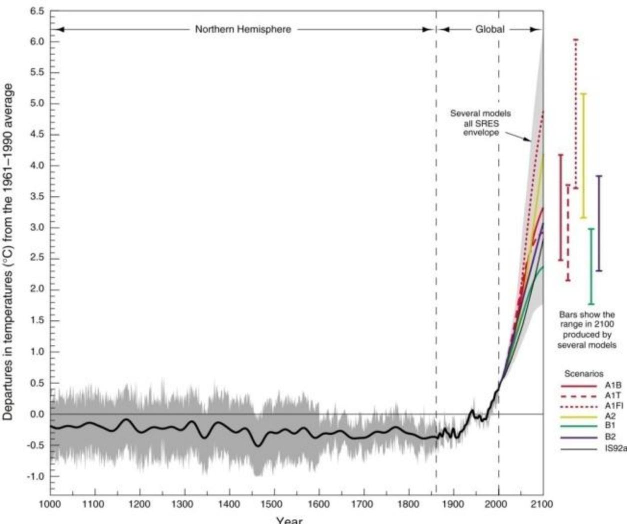


AZ Climate Division 7 Standardized Precipitation Index - (1-60 mos,1980-2012)
1
2
3
4
5
6
7
-3
-2
-1
0
1
2
3
DRY
Average
WET
Long-term Drought
Short-term Drought
SPI Length(mos)
Precip (inches)
Monthly Precipitation Anomaly (in.)
Jan80
Jan85
Jan90
Jan95
Jan00
Jan05
Jan10
Year



AZ Climate Division 7 Standardized Precipitation Index - (1-60 mos,1995-2012)

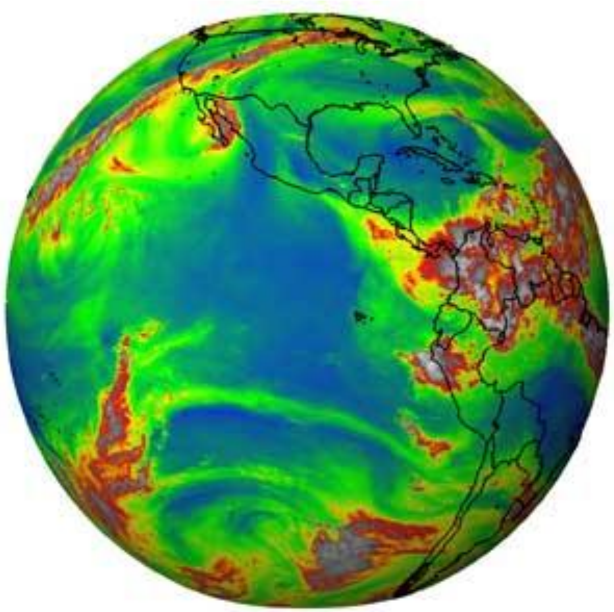




Don Falk

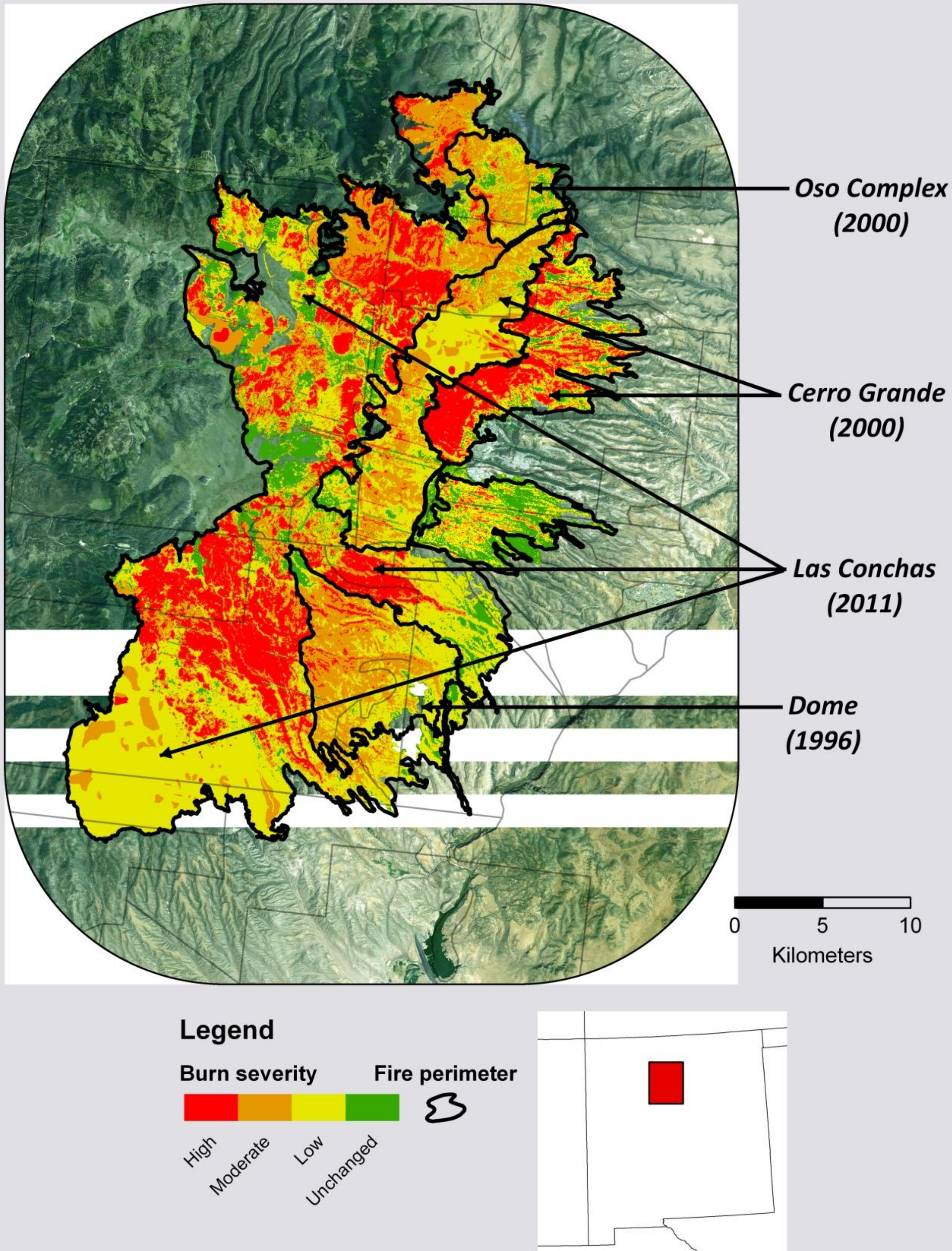
School of Natural Resources and the Environment

University of Arizona



Burns, Re-burns, and Ecological Trajectories

June 2012



1. Large contiguous high-severity patches (10,000 ac)
2. Many are burning into the footprints of previous fires
3. Tipping-point system behavior into new ecosystems?

Figure: A. Thode, NAU

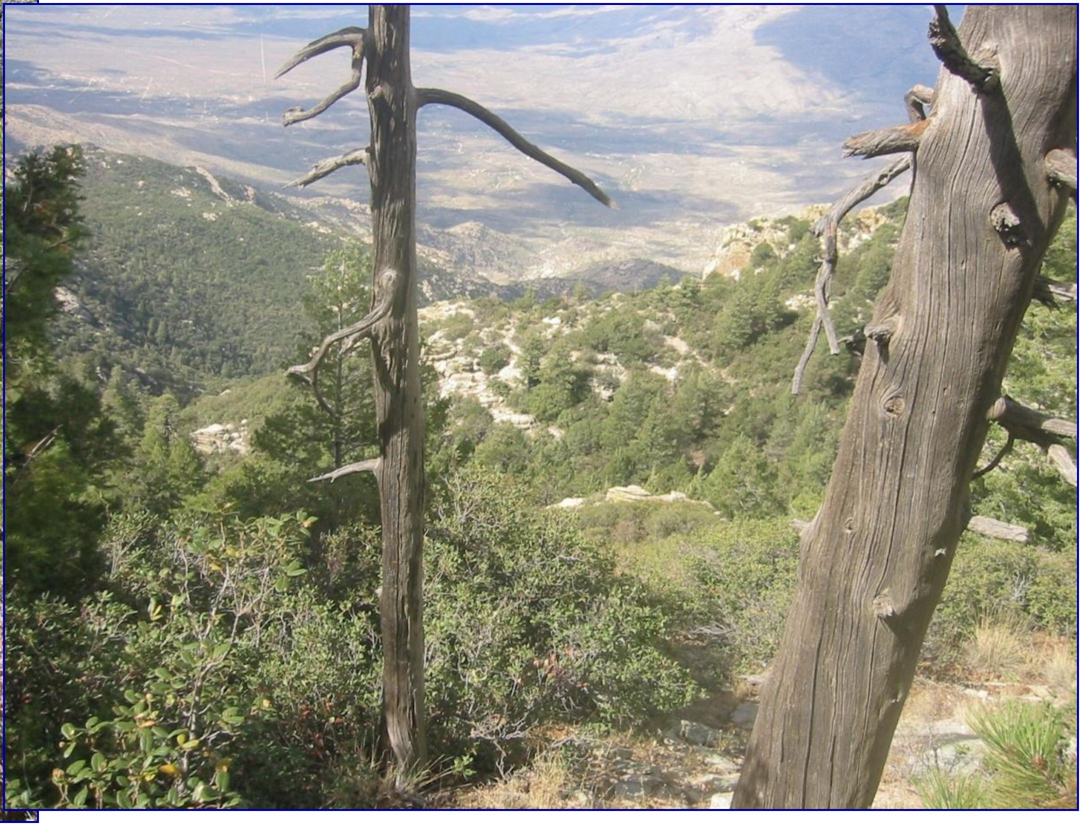

Interactions between climate change, disturbance, and other stressors may lead ecosystems on abrupt new trajectories
Cochiti Canyon, Jemez Mountains, NM, following the 2011 Las Conchas Fire

Why does disturbance trigger abrupt ecological transitions?

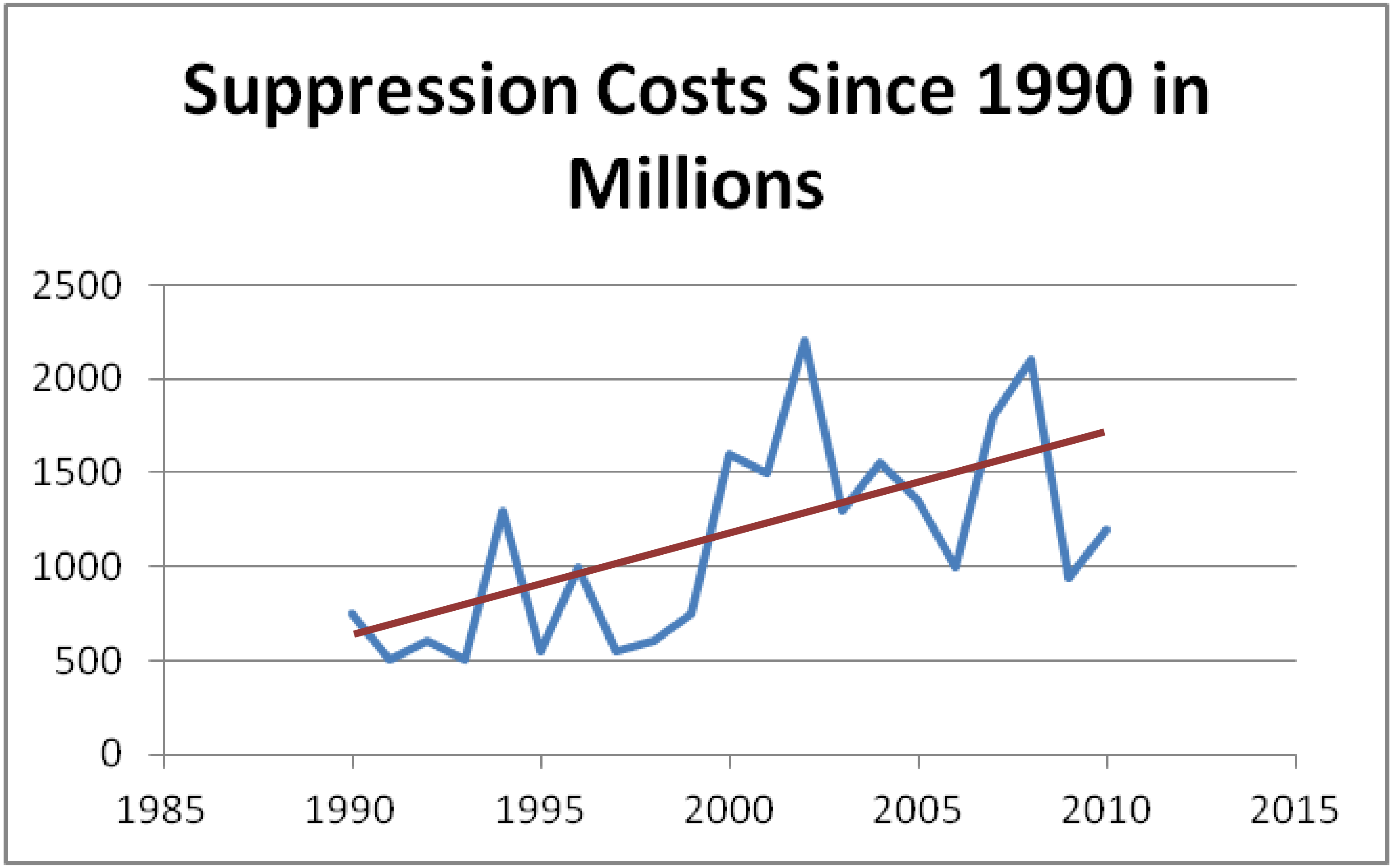
1. Widespread **mortality** of pre-disturbance vegetation
2. **Large high-severity patches** require recolonization
3. Extensive and adverse alteration of **soil and hydrologic conditions**
4. In some cases, **opportunistic species** capture site
5. **Regeneration** impeded under in current **climate**

Severe fires can trigger type conversions to new stable equilibria

SW white pine snags with multiple fire scars in an oak shrub field originating after 1867 stand replacing fire, Rincon Mts. (Photos: J. Iniguez)

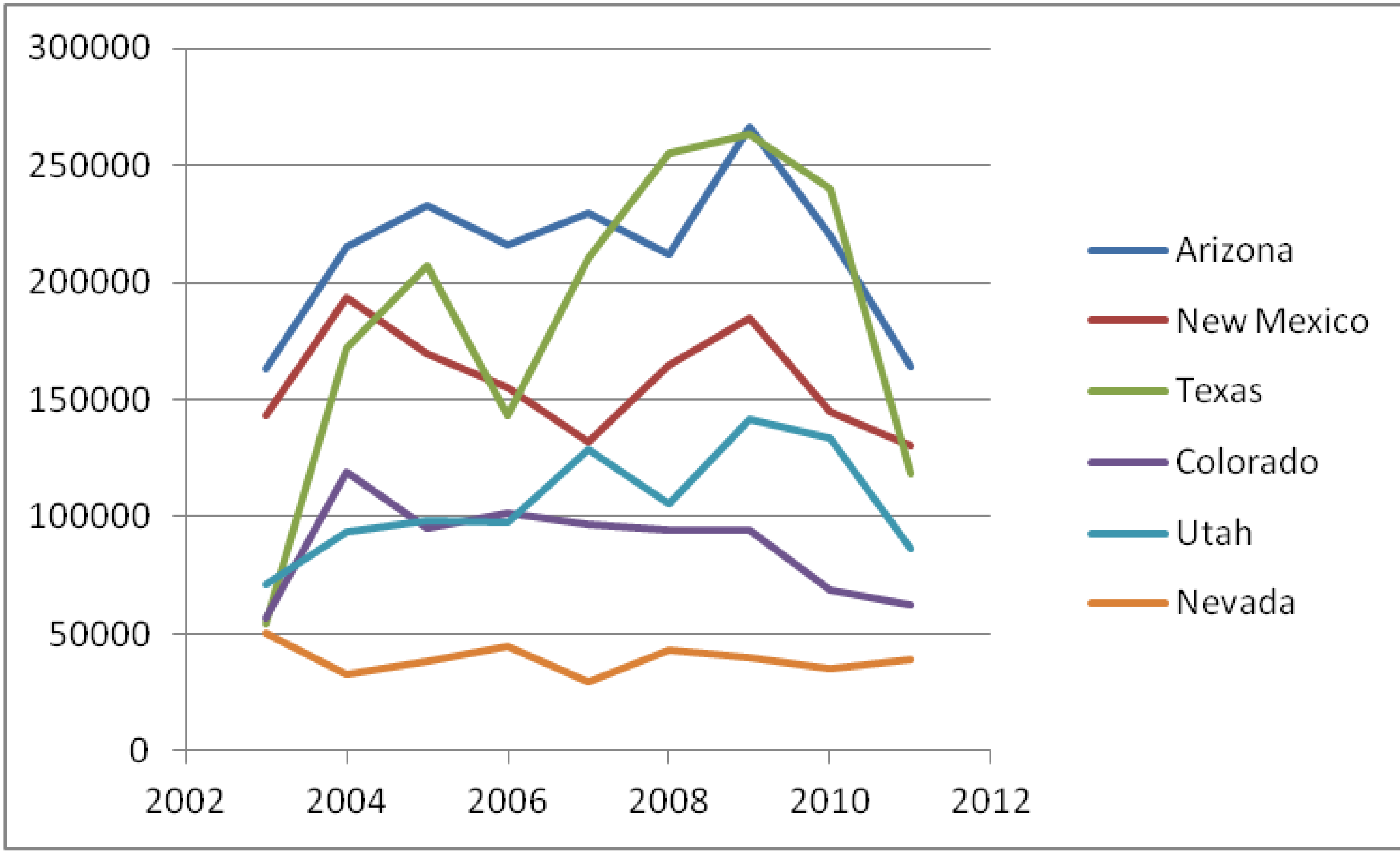


The ongoing focus on suppression is an expensive pathway…



Adapted from Holmes et al. 2007 .

Are we keeping up with the challenges of fuels and climate?

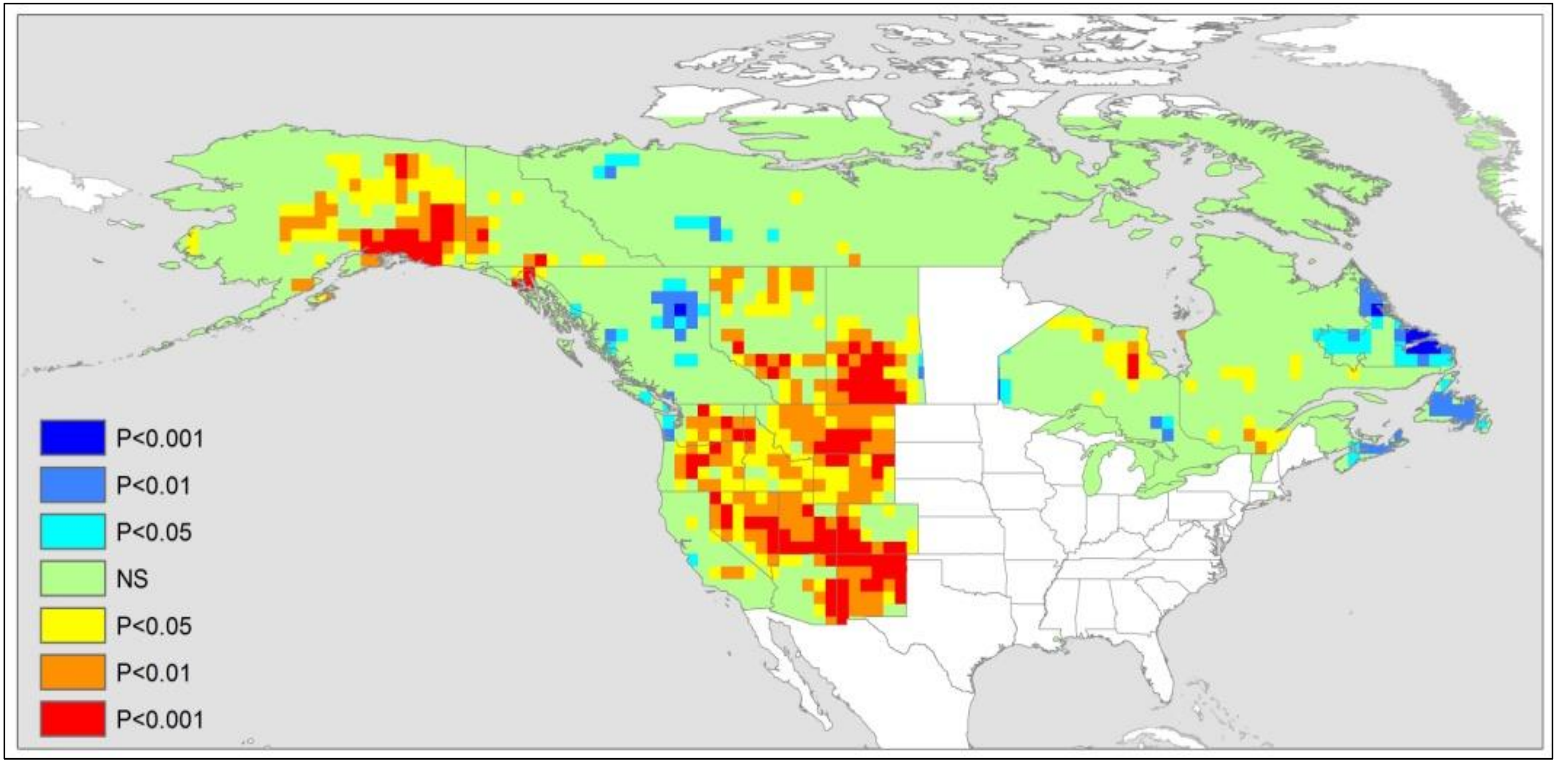


Conver *et al.*, in prep.

Is there a better alternative?

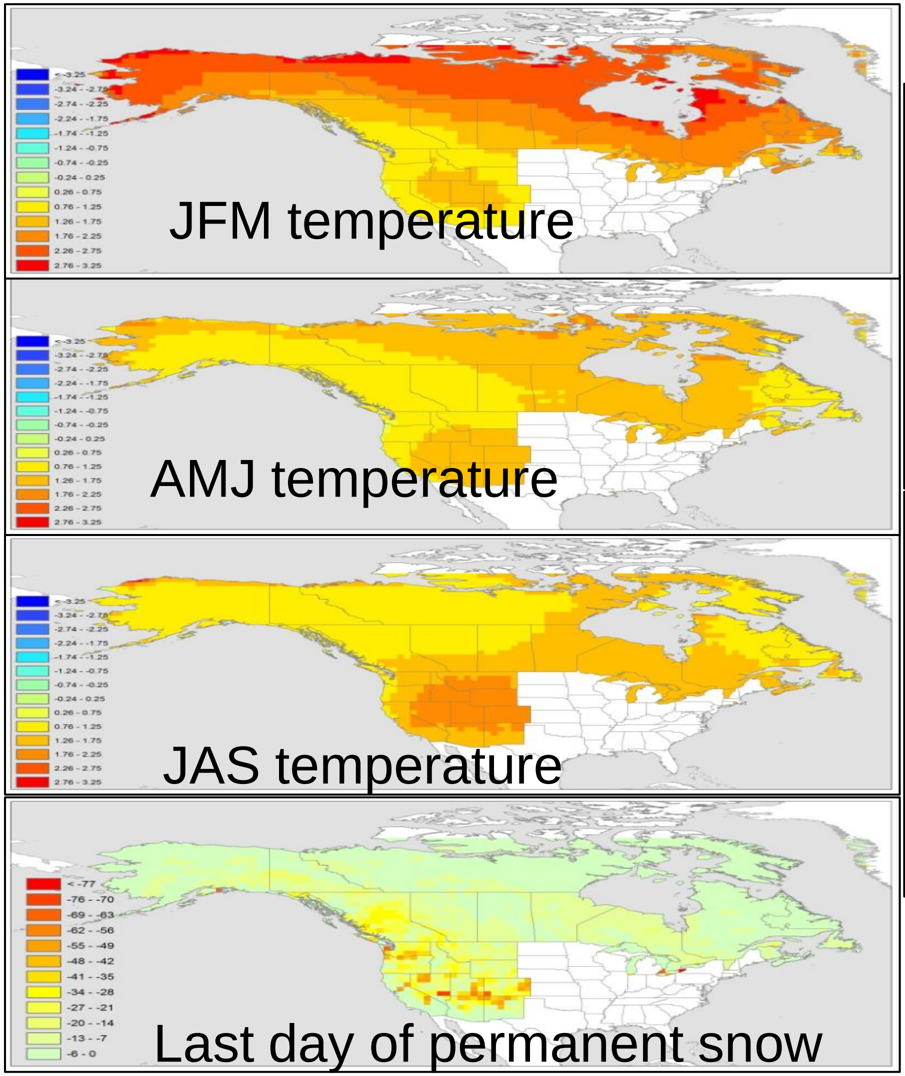
- Fire suppression costs alone $500-1,000/ac, <u>not including</u> burned area rehabilitation, insurance and property losses
- Investing just 10% of the $1.2 billion suppression budget in restoration would treat more than a million acres <u>per year</u> and employ thousands of people
- **Restoration must be redefined as an investment, not a "cost" to be avoided**

Trend in annual area burned 1972-2004

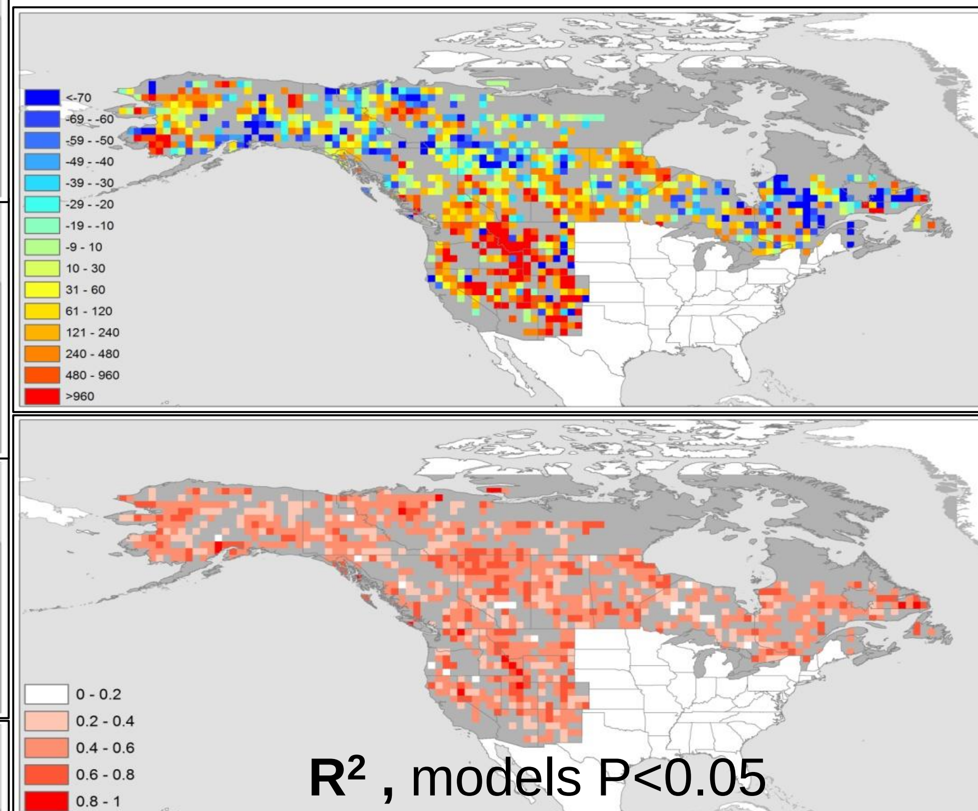


Significance of trend, Mann-Kendall Test

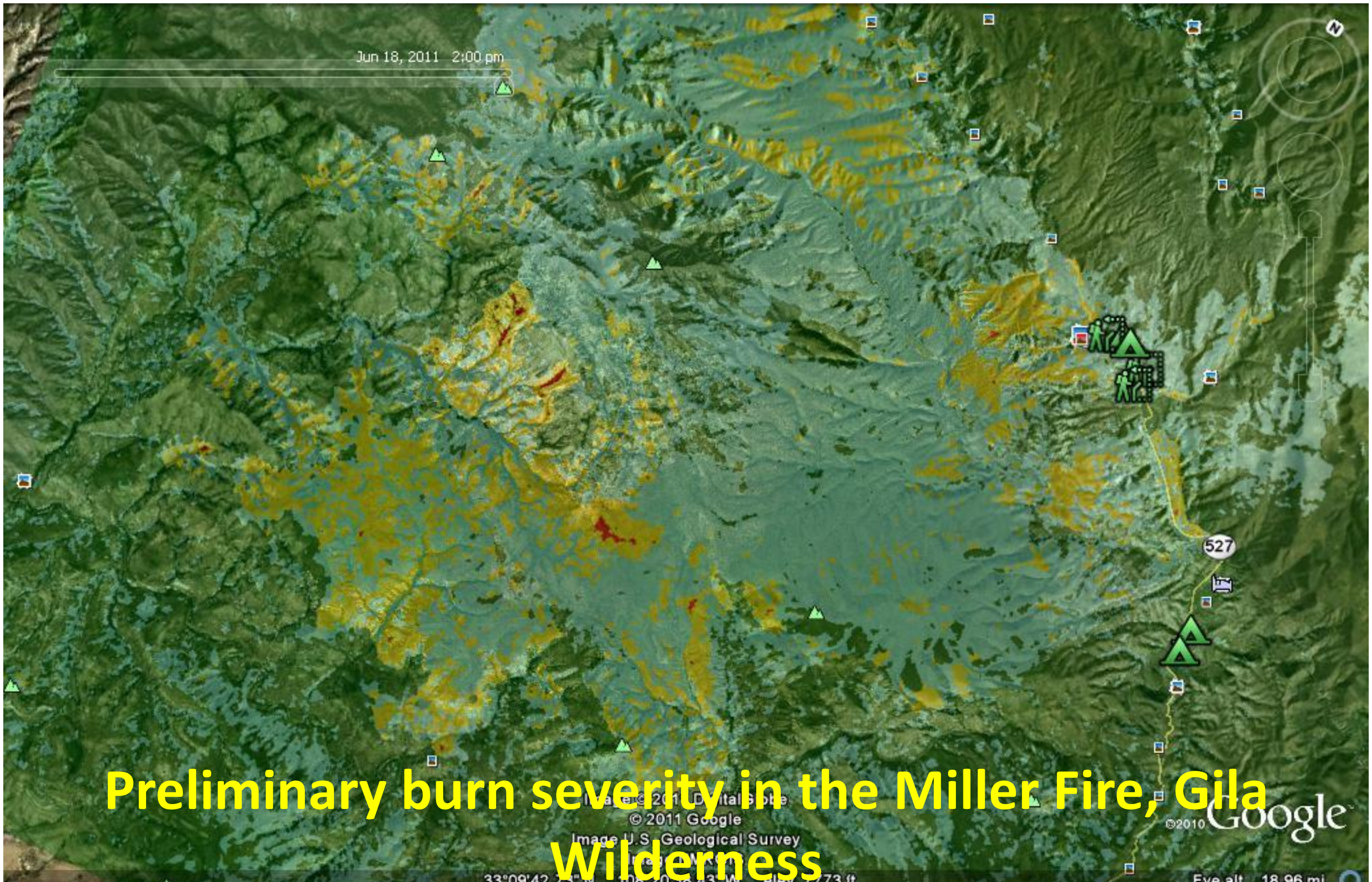
Projected change in climate (2010-2039 *vs.* 1961-1990), A1B



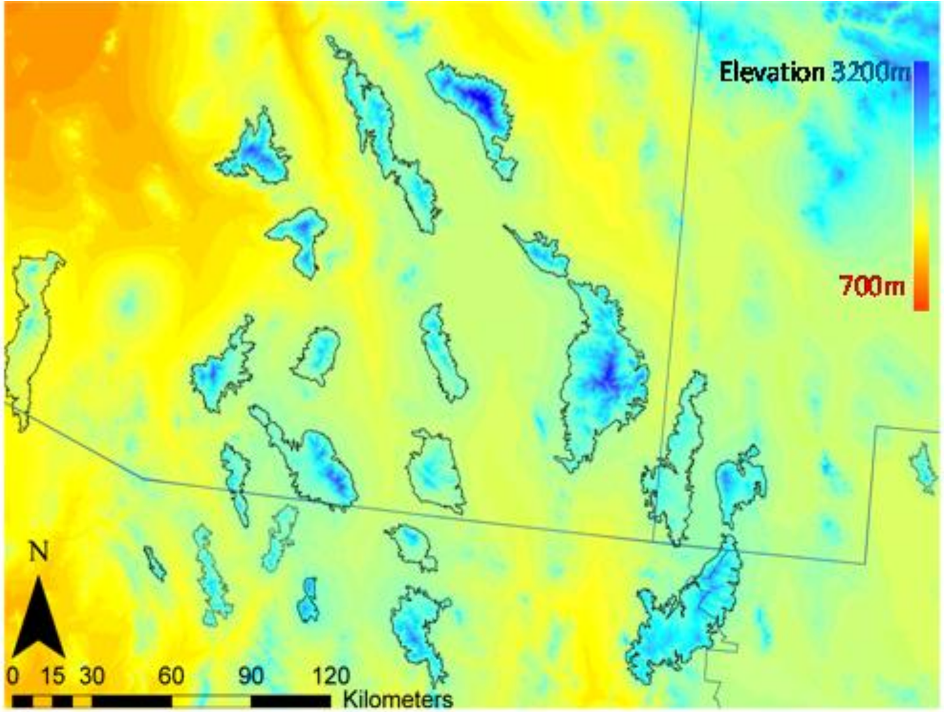
Projected percent change in annual area burned (2010-2039 *vs.* 1961-2004) A1B



Miller Fire: An important reference fire that demonstrates what happens when fire is allowed to stay in the system



Preliminary burn severity in the Miller Fire, Gila Wilderness



FireScape: Restoring fire and ecosystems at large scales in the Sky Islands bioregion?

www.azfirescape.org

2012 Monsoon Outlook for Southeast Arizona

What is the forecast?

How do we make that forecast?

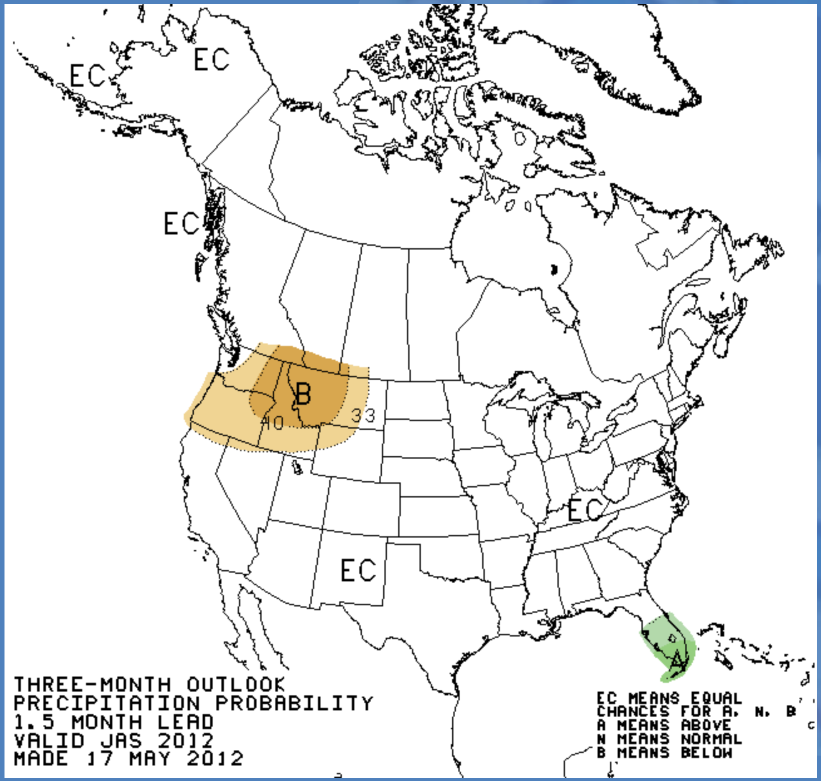
What are the forecast limitations?

What are the impacts?

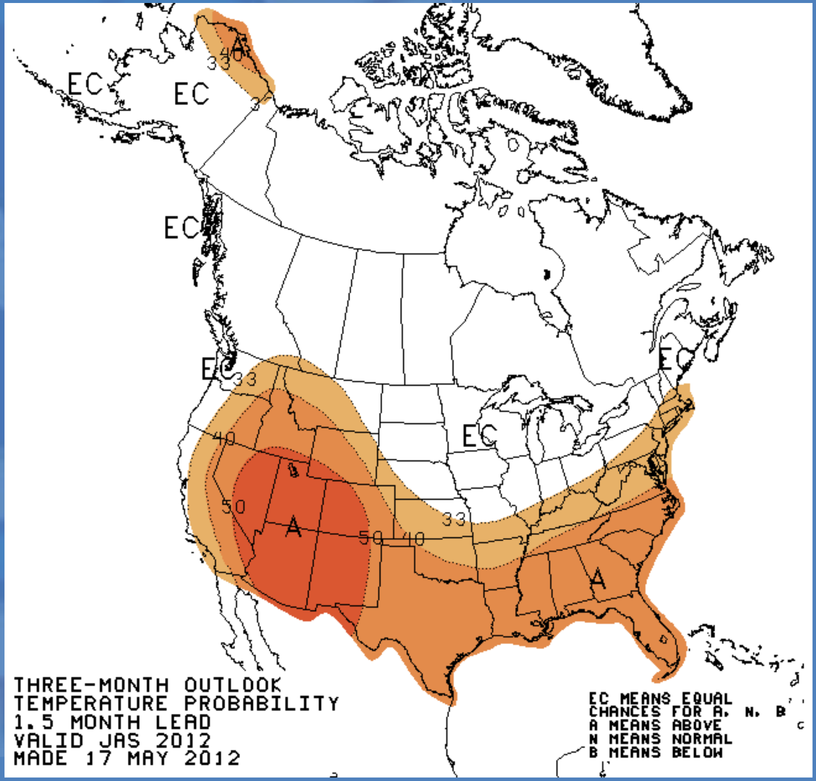
John Brost
Science and Operations Officer
NWS Tucson, AZ

What Can We Expect?
Official Climate Prediction Center Forecast

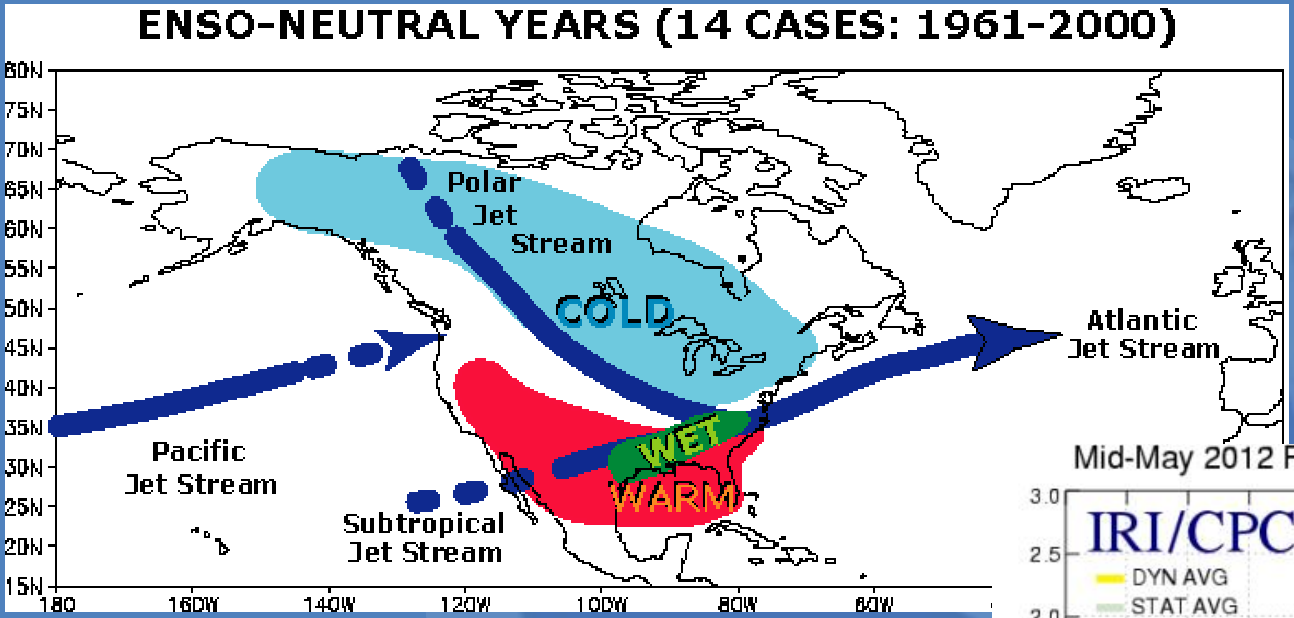
July/August/September Precipitation Outlook



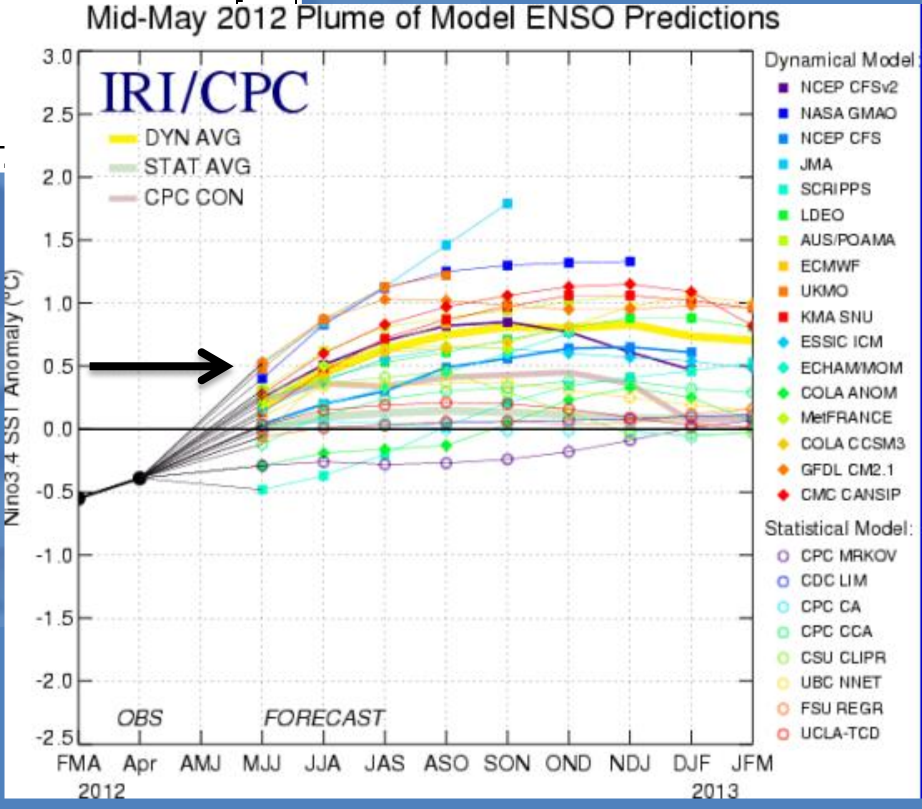
July/August/September Temperature Outlook



Start With ENSO – Currently "Neutral"



Most forecast models suggest El Nino conditions will begin by late summer.



Monsooon Rainfall totals at Tucson following a winter La Niña which transitioned to ENSO neutral during the Spring.

- Normal Monsoon rainfall = 6.08 inches.

LaNina Winter	Monsoon Rainfall	ENSO neutral began
1950-51	4.49"	Feb/Mar/Apr Then El Nino began June/July/Aug
1956-57*	5.26"	Dec/Jan/Feb Then El Nino began March/April/May
1962-63#	5.97"	Dec/Jan/Feb Then El Nino began May/June/July
1964-65	4.07"	Jan/Feb/March Then El Nino began April/May/June
1967-68#	3.09"	April/May/June Then El Nino began July/Aug/Sept
1971-72*	8.01"	Jan/Feb/March Then El Nino began April/May/June
1975-76	3.19"	April/May/June Then El Nino began Aug/Sept/Oct
1983-84#	9.94"	Jan/Feb/March and Persisted Through Monsoon
1988-89	2.40"	May/June/July and Persisted Through Monsoon
1995-96	7.43"	March/April/May and Persisted Through Monsoon
2000-01*	2.81"	March/April/May and Persisted Through Monsoon
2005-2006	10.20"	March/April/May El Nino began Aug/Sept/Oct
2008-09#*	2.86"	March/April/May El Nino began June/July/Aug
2010-11	8.62"	April/May/June and Persisted Through Monsoon

*Previous winter was moderate to strong La Nina

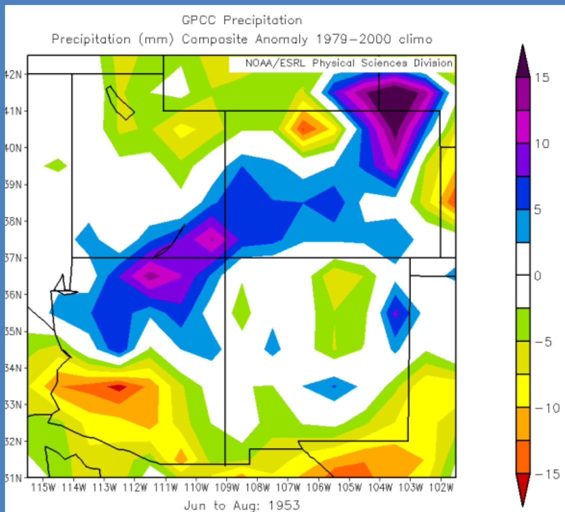
#Not True La Nina…Not 5 overlapping (3-month) seasons of < or = -0.5

Similar Years in the Past as a Predictor

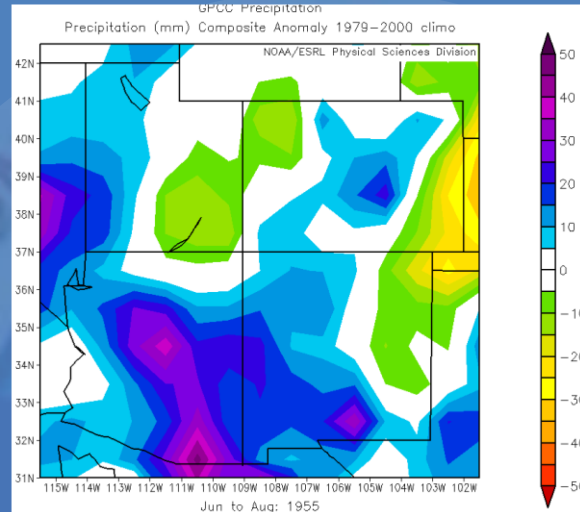
- **Look at a wide array of climate signals and see if there are similar years in the past**
- ***1953, 1955, 1960, 1995*, 1999, *2000***

How Did they turn out???

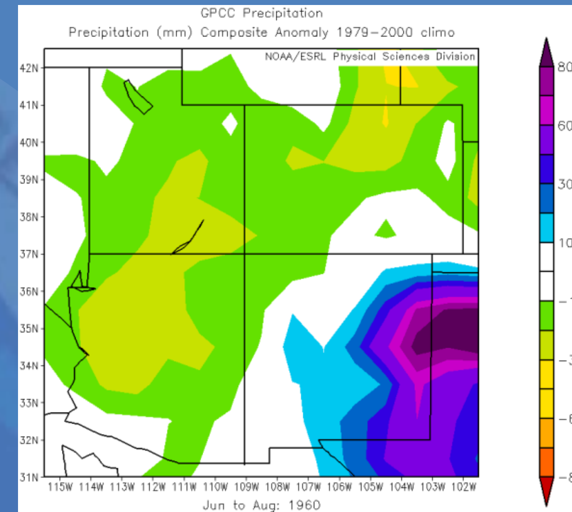
Breaking it Down by Year



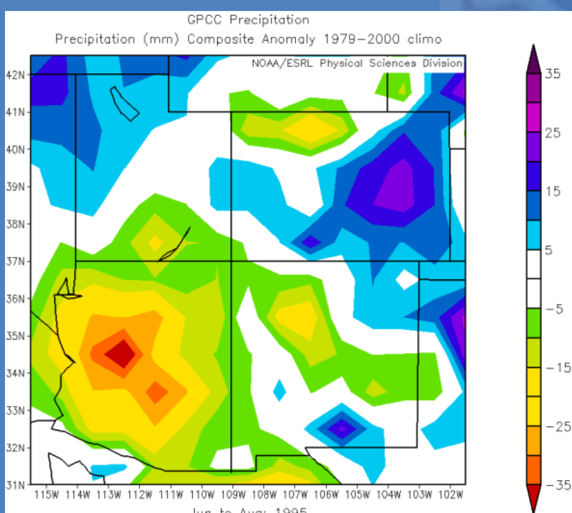
1953 (Mixed)



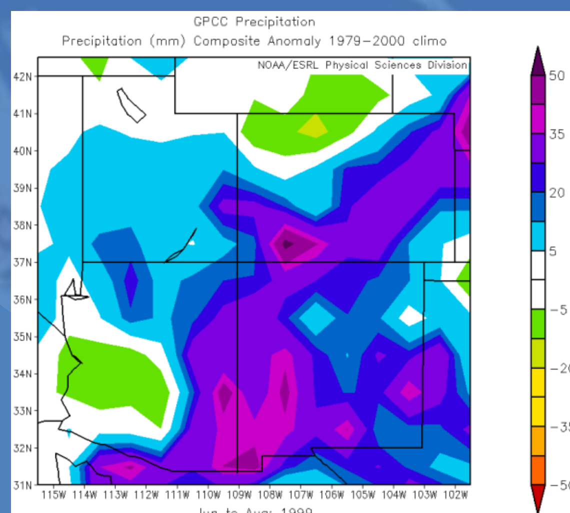
1955 (Wet)



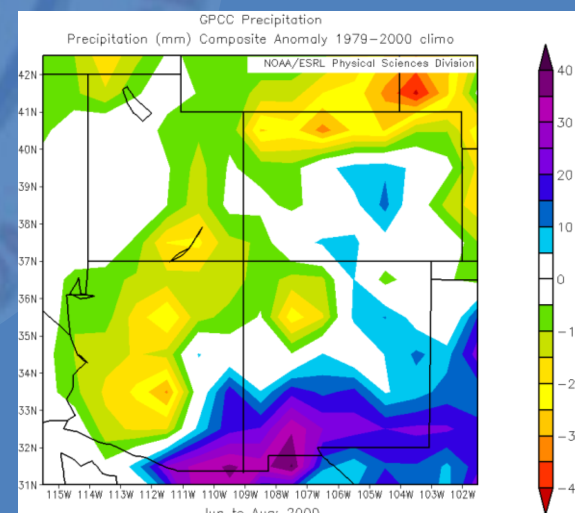
1960 (Dry)



1995 (Dry)



1999 (Wet)



2000 (Mixed)

Bottom Line

- Given the lack of strong signals, an equal chances forecast makes the most sense.
- There is some indication that we might "start off with a bang" like last year – but we are unsure what the rest of the season holds.
- What we know
  - There will be storms
  - There will be severe weather

Thank You

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Big Thanks to:

Dr. Chris Castro, University of Arizona

Mr. Stephen Bieda, 25th Operational Weather Squadron (Davis Monthan AFB)

Mr. Jon Gottschalk, Climate Prediction Center

What do tree rings tell us about monsoon rainfall over past centuries?

Daniel Griffin* & Connie A. Woodhouse

Laboratory of Tree-Ring Research

School of Geography and Development

Each tree ring = 2 components

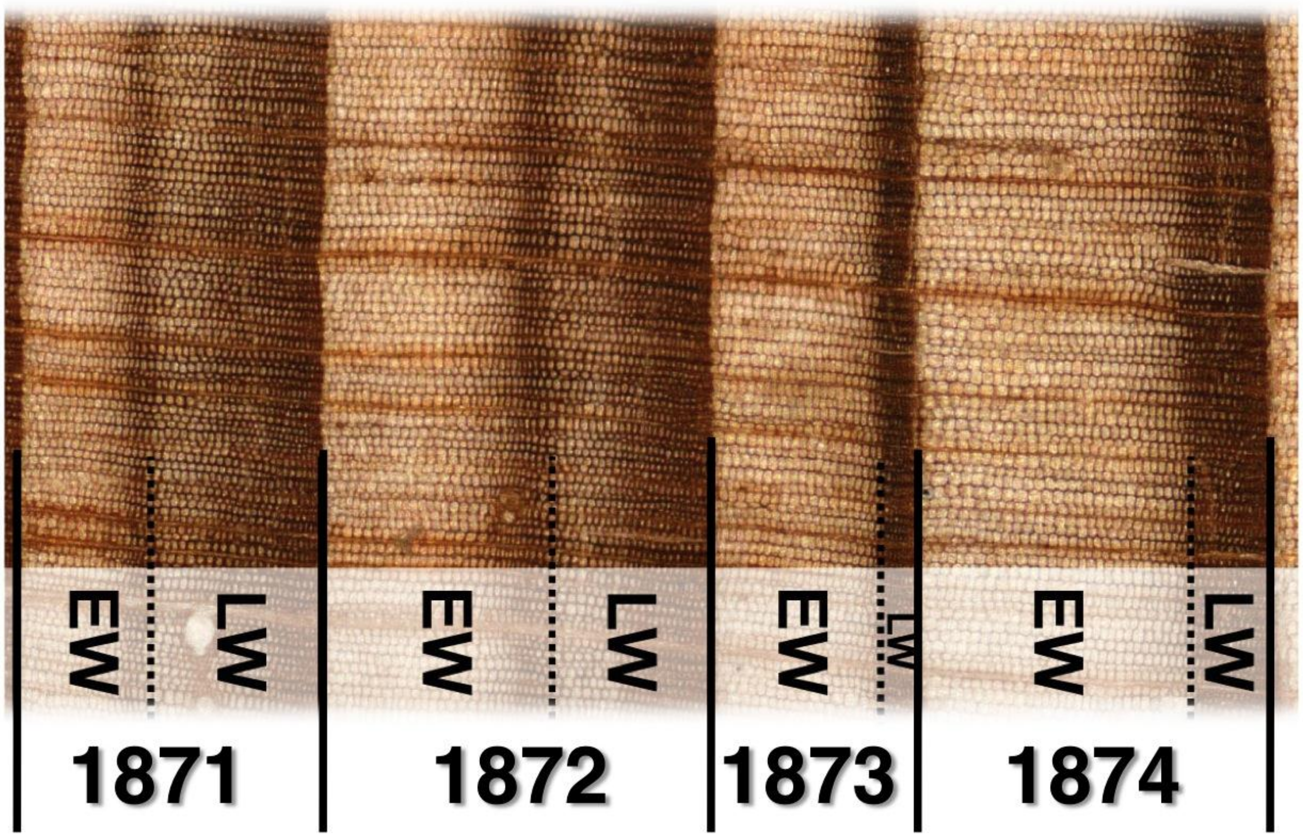
1) **EARLYWOOD** (light color, forms in spring)

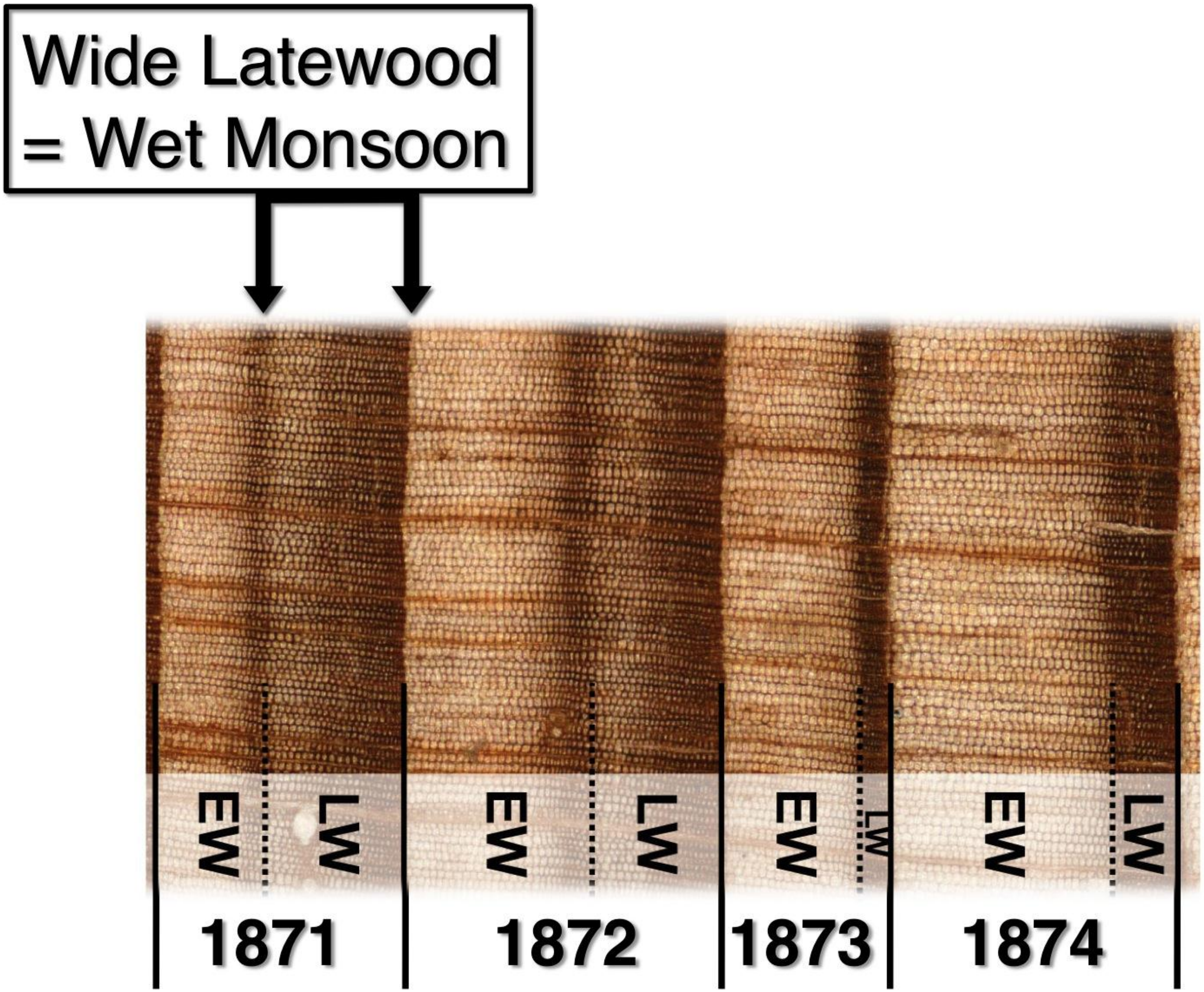
2) **LATEWOOD** (dark color, forms in summer)

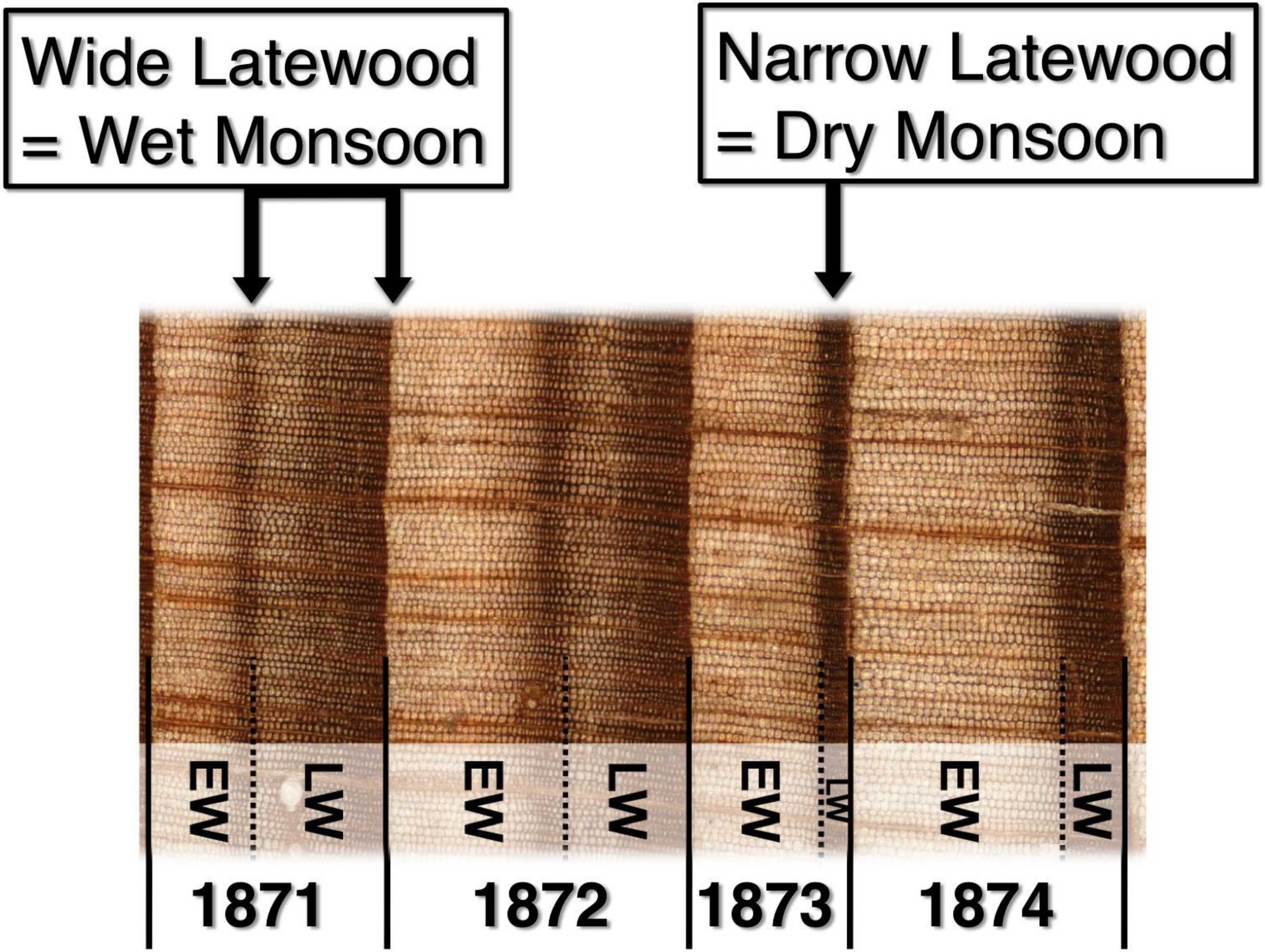
Each tree ring = 2 components

1) **EARLYWOOD** (light color, forms in spring)

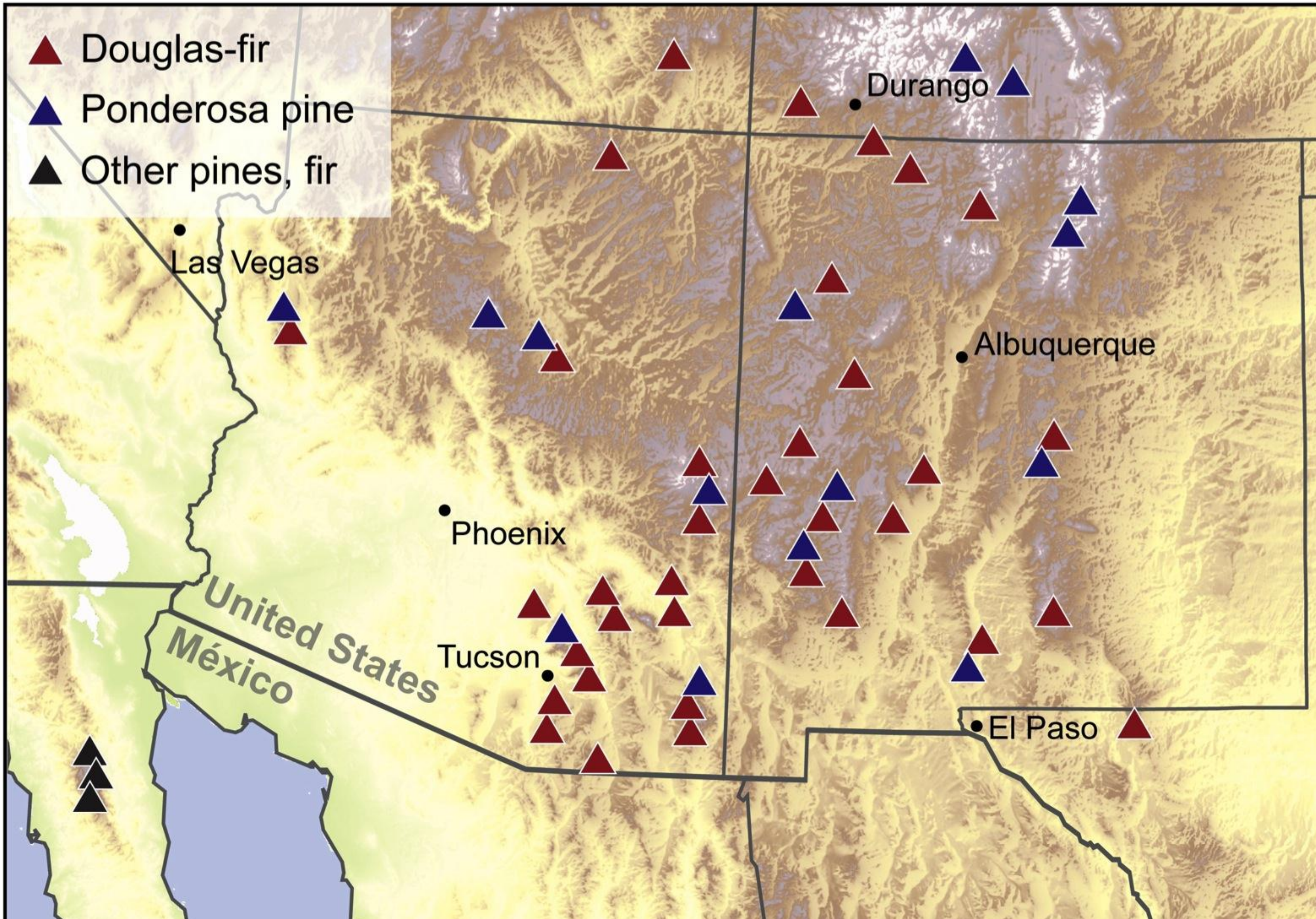
2) **LATEWOOD** (dark color, forms in summer)



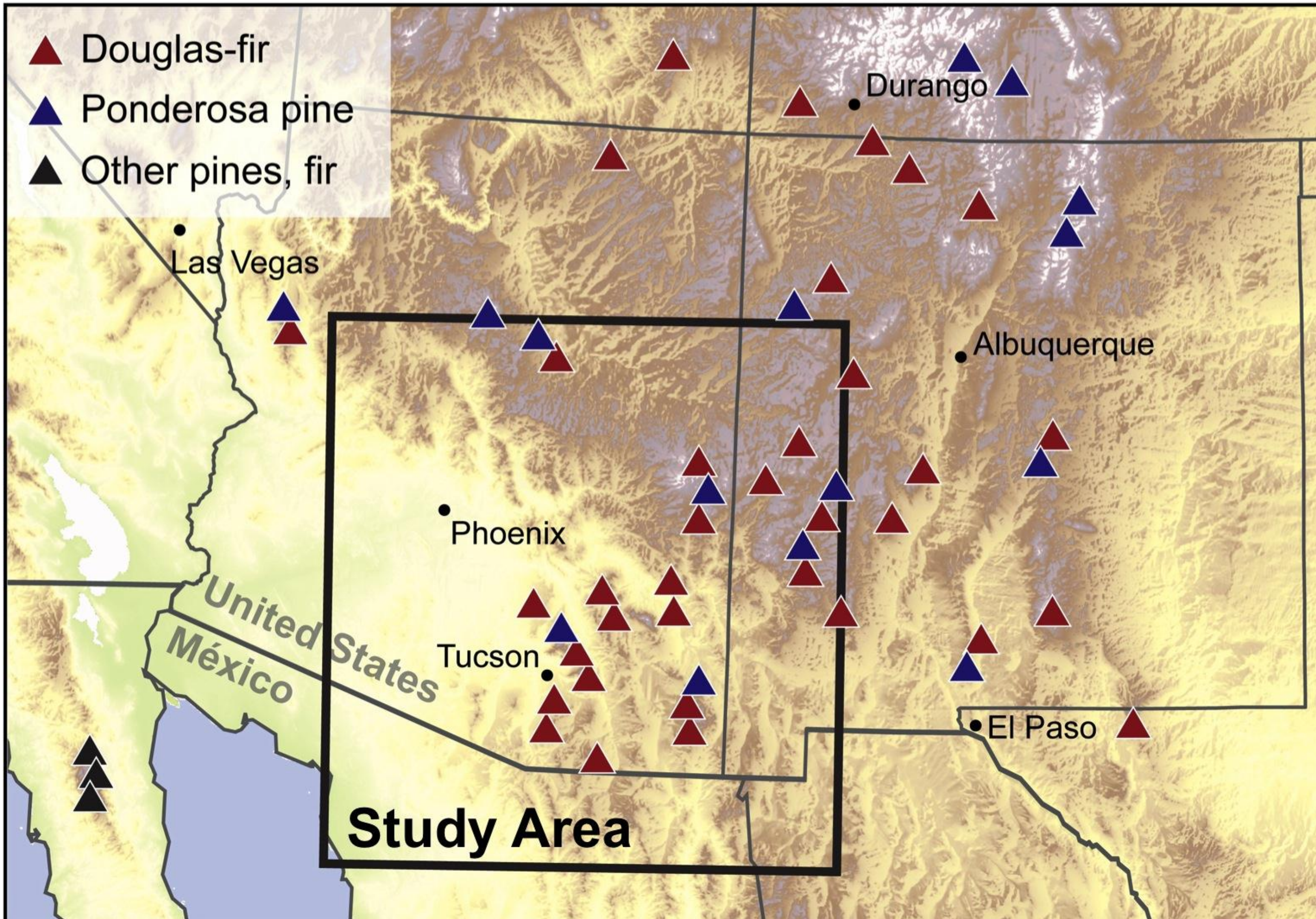

Wide Latewood
= Wet Monsoon
EW
LW
EW
LW
EW
LW
EW
LW
1871
1872
1873
1874


Wide Latewood
= Wet Monsoon
Narrow Latewood
= Dry Monsoon
EW
LW
EW
LW
EW
LW
EW
LW
1871
1872
1873
1874

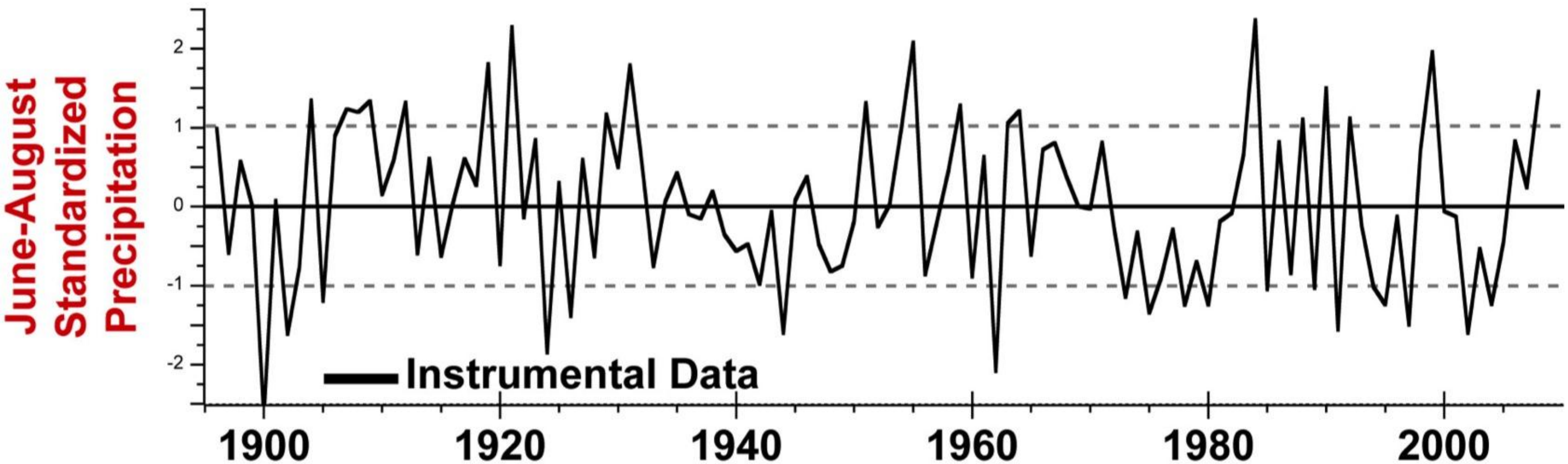
A new network of latewood tree-ring records



A new network of latewood tree-ring records
A new reconstruction of monsoon rainfall

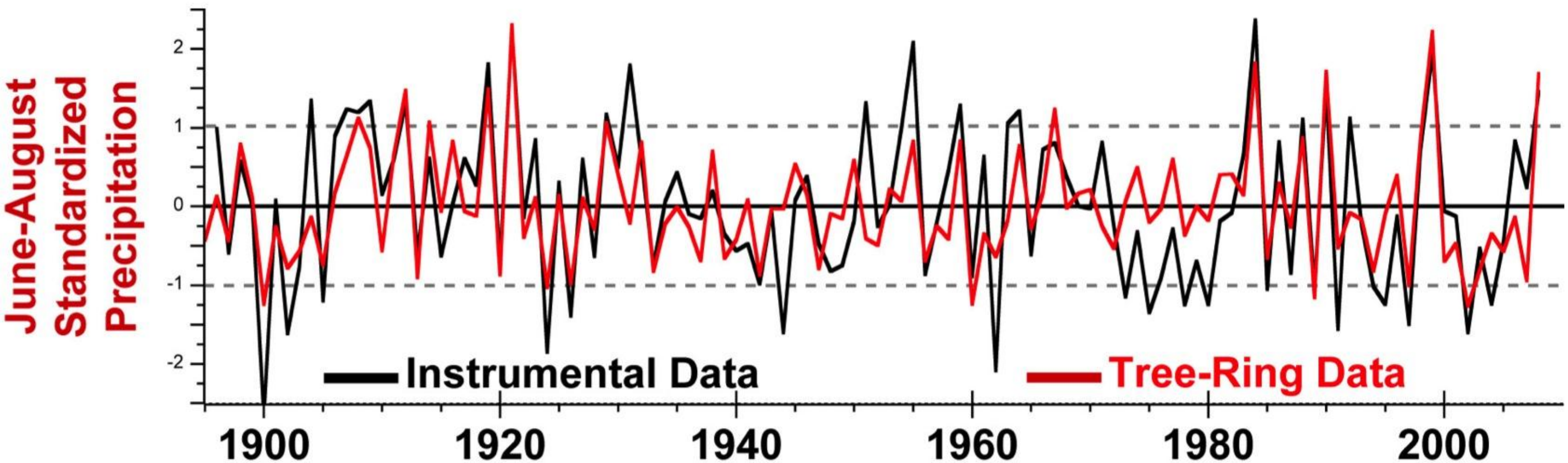


A new reconstruction of monsoon rainfall

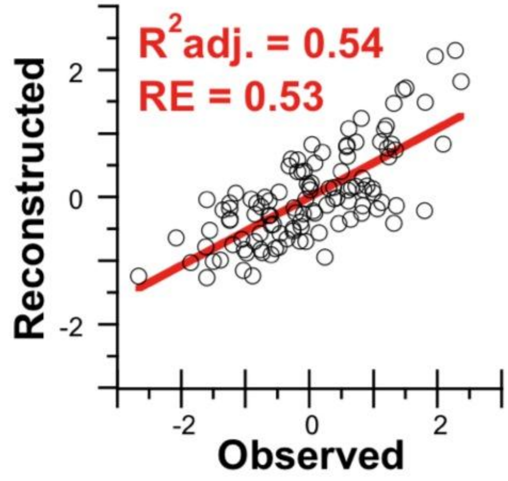


Griffin, Woodhouse et al. *in preparation*

A new reconstruction of monsoon rainfall

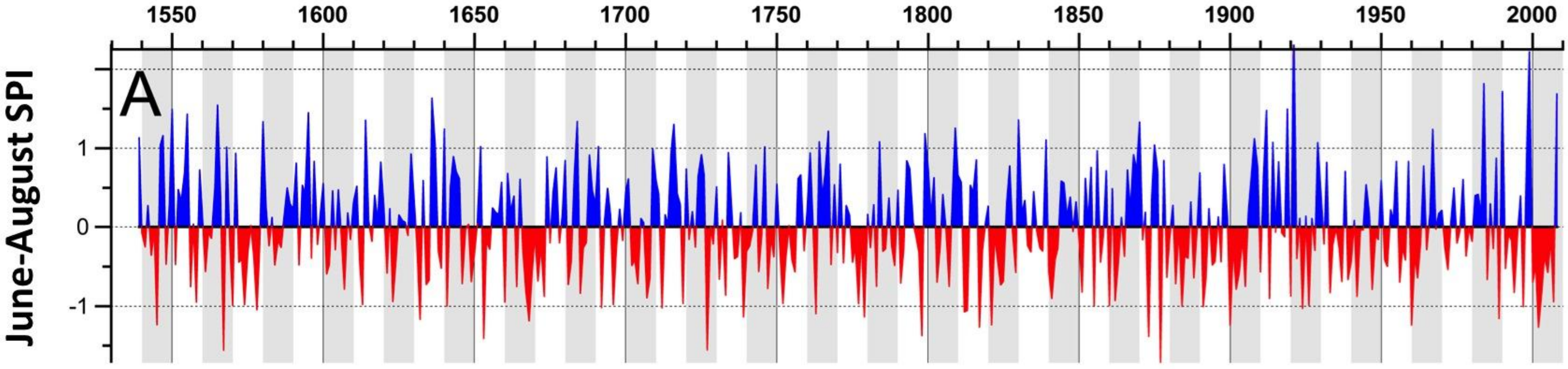


From 1896-2008, the latewood record shares 54% of the variability with rain gauge records



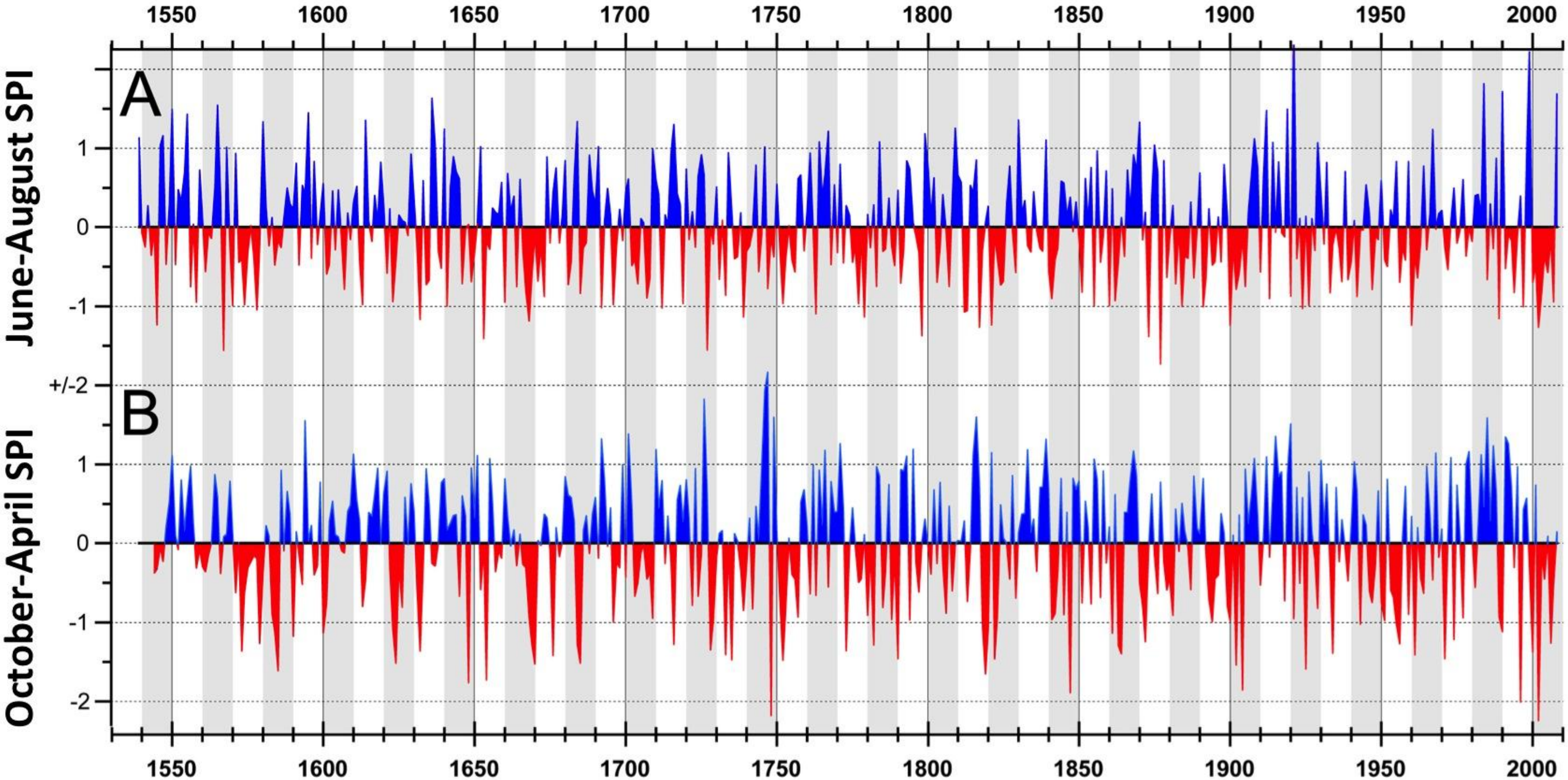
Griffin, Woodhouse et al. *in preparation*

450-year reconstruction of monsoon rainfall



Griffin, Woodhouse et al. *in preparation*

450-year reconstruction of monsoon rainfall

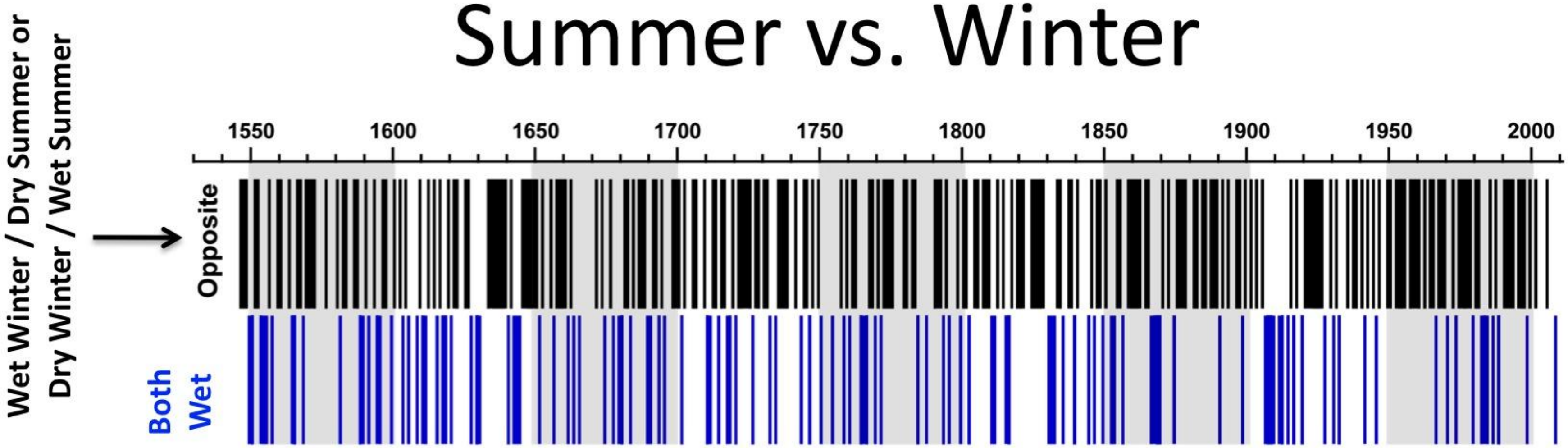


companion reconstruction of winter-spring precipitation

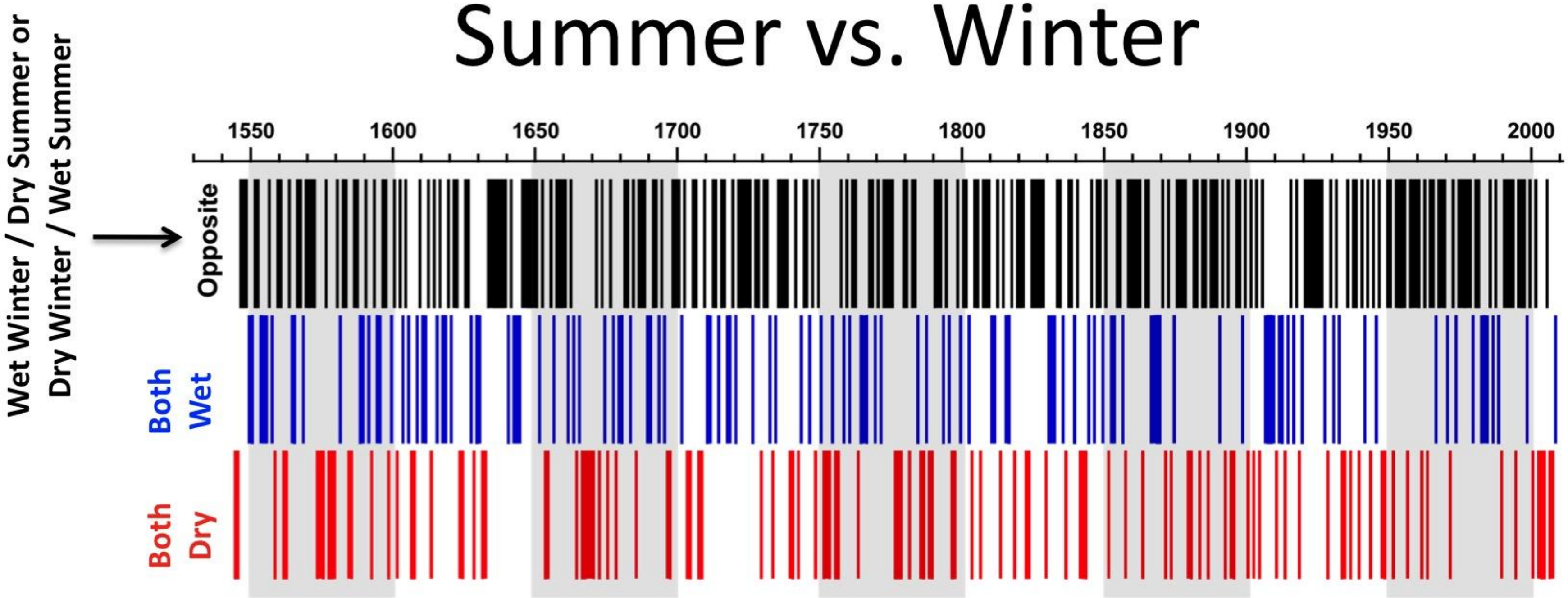
Griffin, Woodhouse et al. *in preparation*

Summer vs. Winter

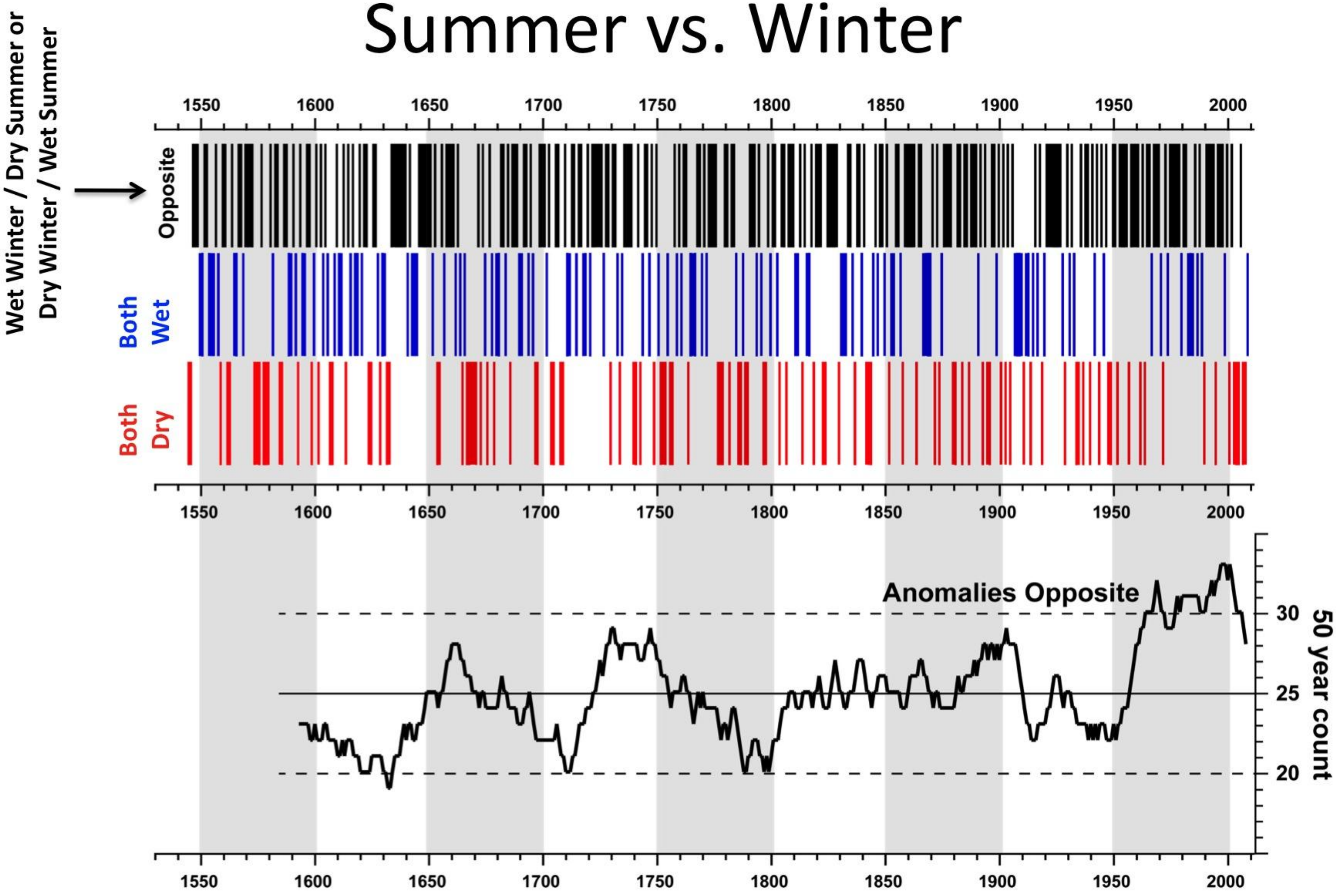
Summer vs. Winter



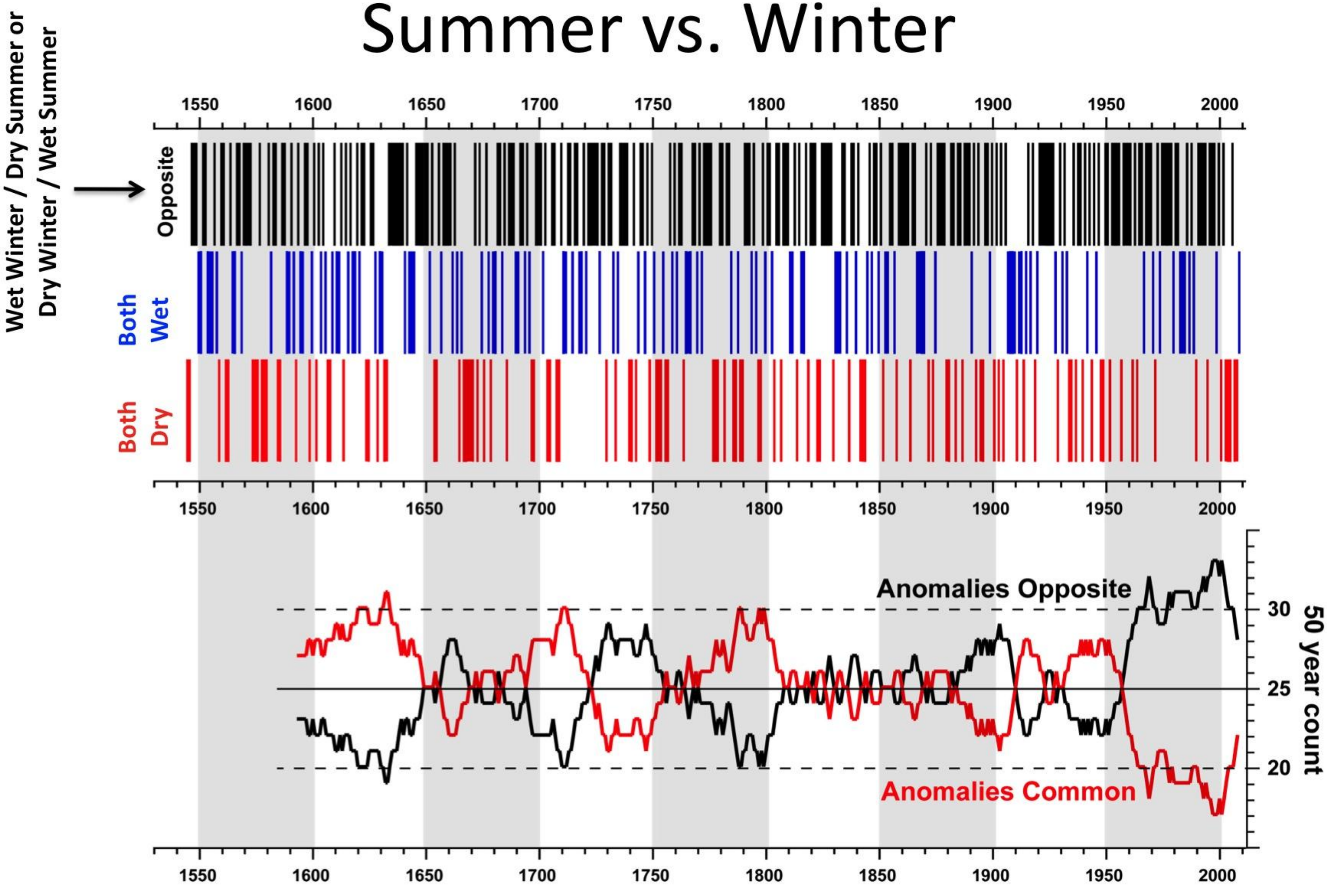
Summer vs. Winter



Summer vs. Winter



Summer vs. Winter



Daniel Griffin
dgriffin@email.arizona.edu

The take away….

1) Tree-ring "latewood" reflects monsoon moisture conditions.
2) Tree rings show more variability in monsoon drought and wetness than do the rain gauge records alone.
3) The relationship between winter and summer moisture variability appears unstable through time.

THE UNIVERSITY OF ARIZONA
LTRR LABORATORY OF TREE-RING RESEARCH THE UNIVERSITY OF ARIZONA
CLIMAS Climate Assessment for the Southwest
NSF
EPA

COsmic-ray Soil Moisture Observing System (COSMOS)

Trenton Franz[1], M. Zreda[1], WJ. Shuttleworth[1,2], X. Zeng[2], TPA Ferré[1], C. Zweck[1], R. Rosolem[1], S. Stillman[2], and B. Chrisman[1]

[1] Department of Hydrology and Water Resources
[2] Department of Atmospheric Sciences
University of Arizona, USA

With acknowledgements to:
D. Desilets, NSF, Army Research Office, UA Water Sustainability Program, and numerous collaborators at cosmos sites

Hydroinnova and Questa Instruments

COSMOS Project

COsmic-ray Soil Moisture Observing System (COSMOS)

Phase I: NSF project 2009-2013, ~50 US Probes

Phase II: Expansion to 500 probes

Science Priorities:

- Soil moisture controls:
  - weather and climate models
  - ecological processes and phenomena
  - hydrological flow processes in catchments
- Water storage on/in vegetation canopies
- Frozen precipitation
- Remotely sensed measurements of soil moisture

COSMOS Project Status

- Data freely available at http://cosmos.hwr.arizona.edu/, some quality control
- 58 Active probes: 49-Continental USA, 2-Hawaii, 4-Europe, 2-Kenya, 1-Brazil and a few more to come

Location of COSMOS Probes

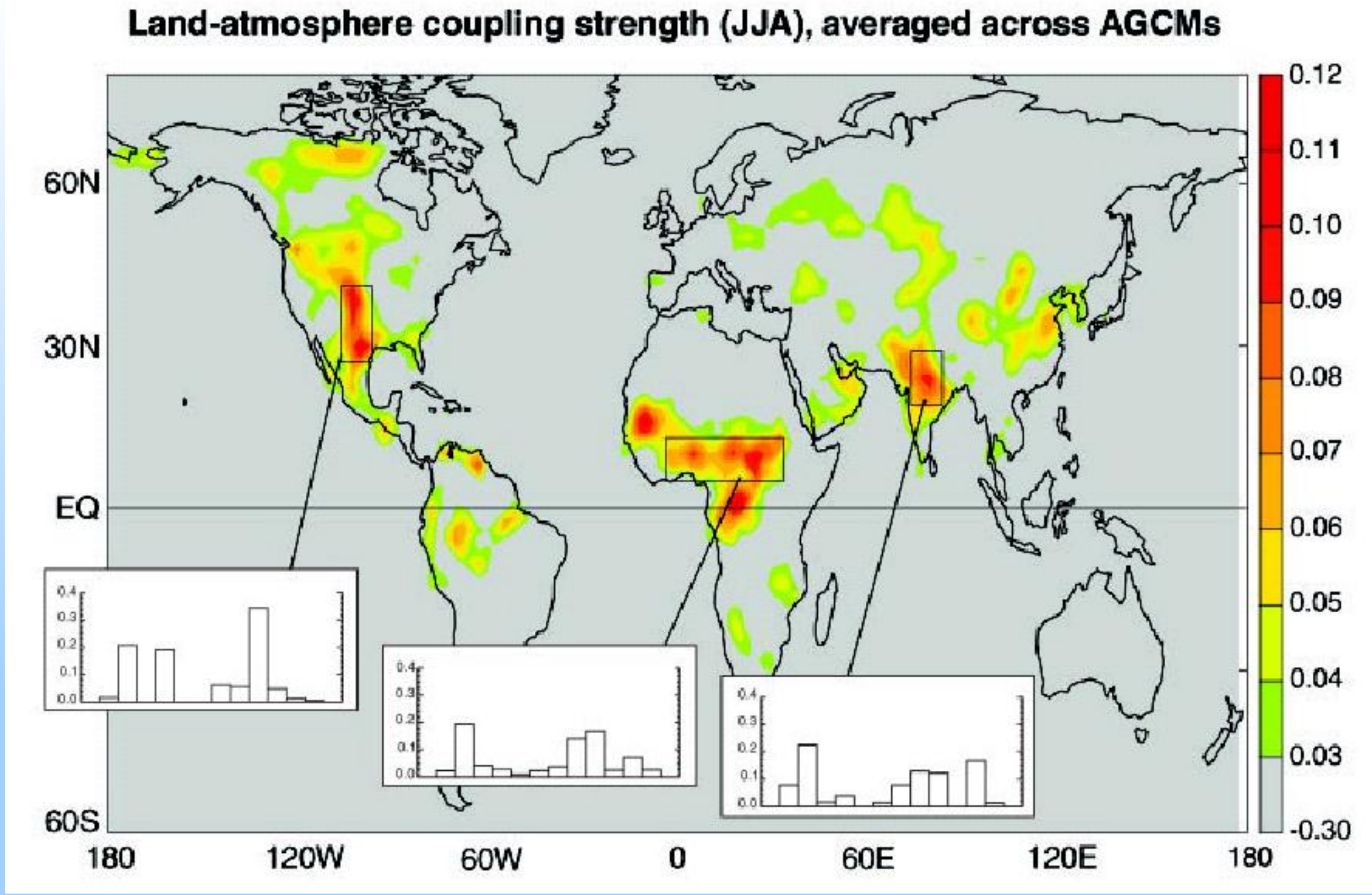
6/11/12 11AM PST

Click on balloons for site descriptions and data access. Station List Diagnostics Utilities

Soil Moisture (V=Volumetric, G=Gravimetric, U=Uncalibrated)

0 – 05% | 05 – 15% | 15 – 25% | 25 – 35% | > 35%

Land-Surface Coupling



(Koester, 2004)

- Land-atmosphere coupling strength: degree to which anomalies in land surface state (e.g. soil moisture) can affect rainfall generation and other atmospheric processes

- Hot spots indicate where a successful initialization of soil moisture may enhance precipitation prediction skill in Northern hemisphere summer

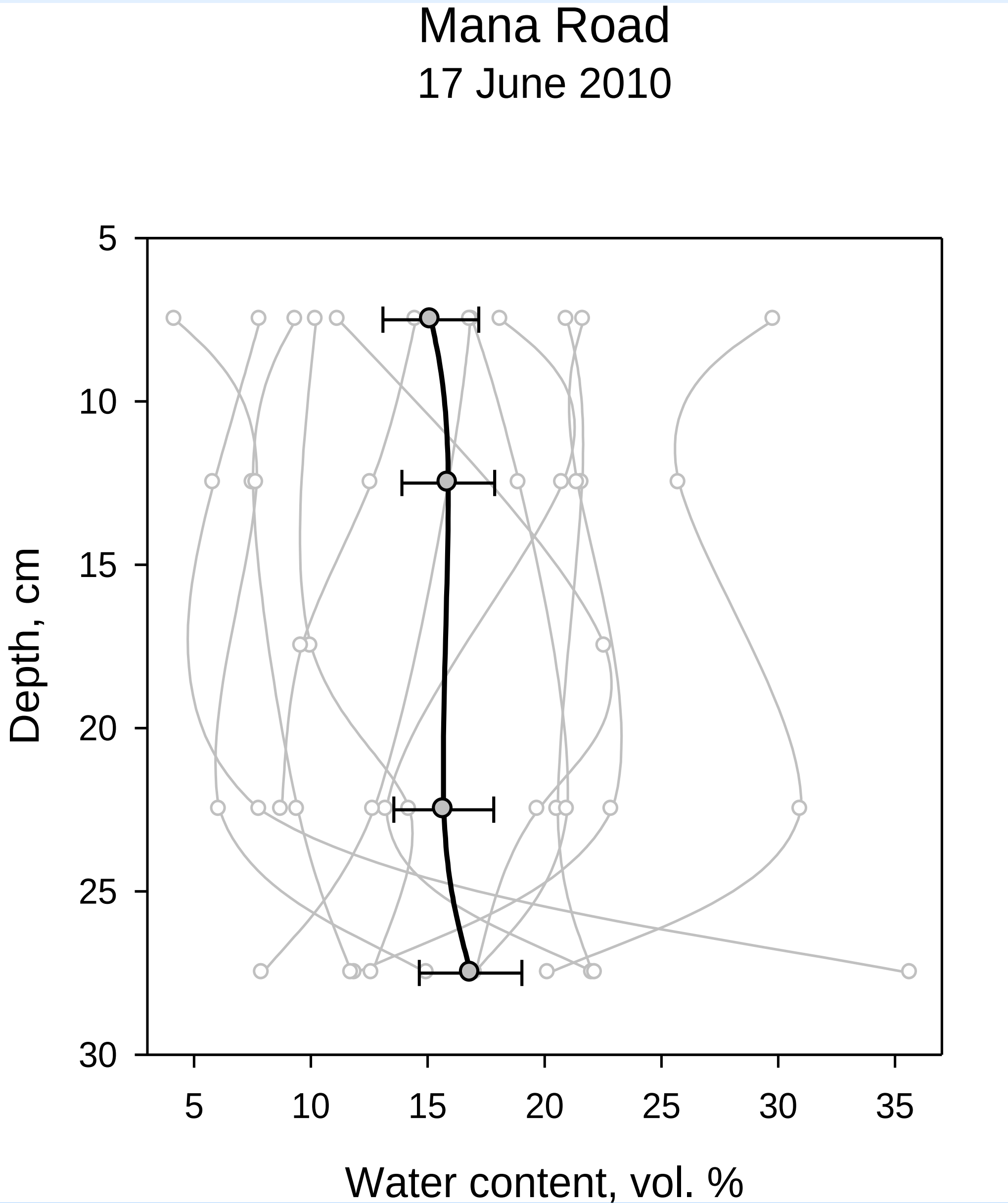
Ecosystem Measurements

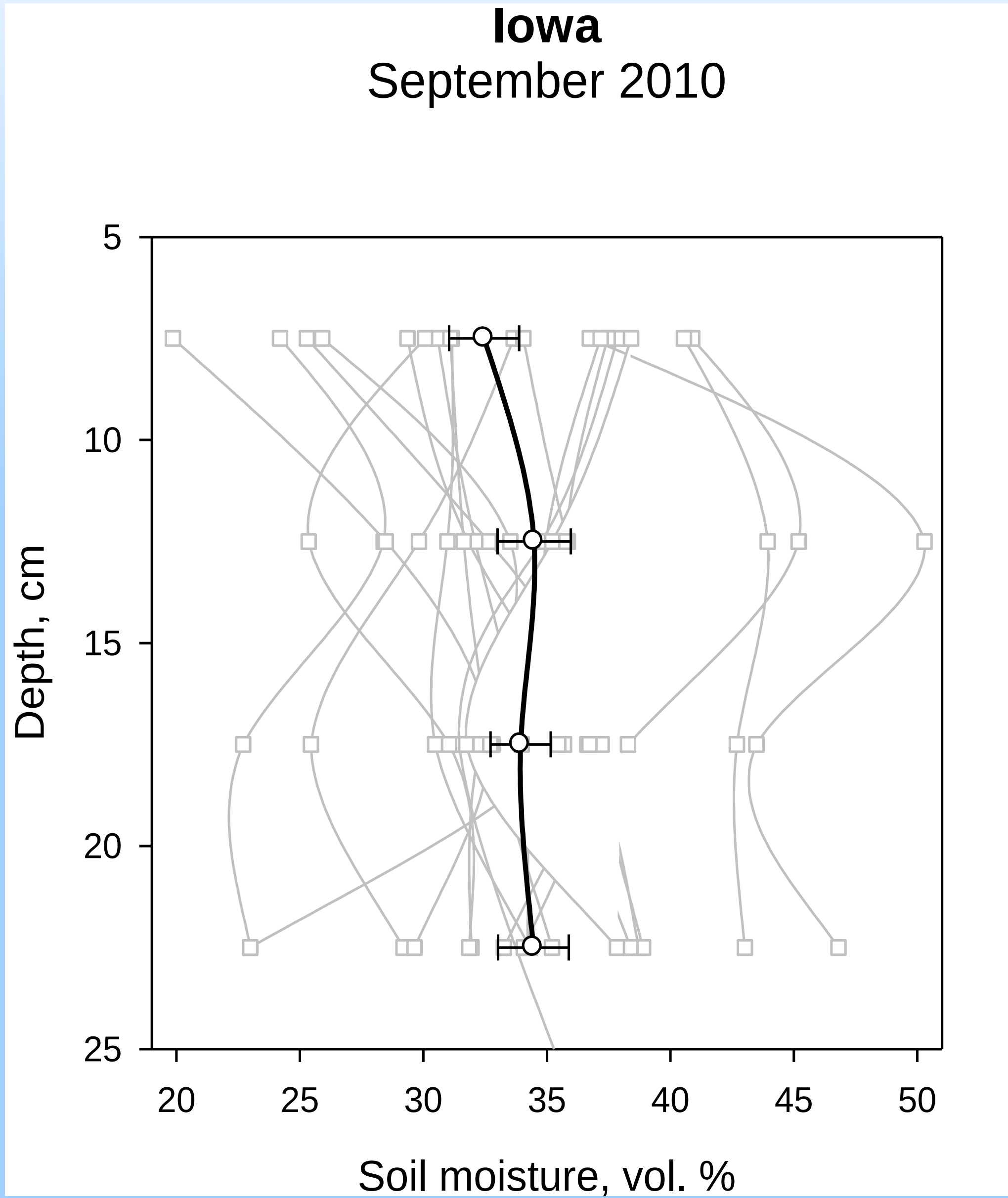
- Energy, Water, and Carbon fluxes measured at intermediate scales with eddy covariance techniques
- Point measurements of soil moisture not necessarily representative of footprint!
- Direct soil moisture measurements at spatial scale time consuming and difficult

Tonzi Ranch, CA June 2011

Variations in Soil Moisture

Collected over 200 m radius





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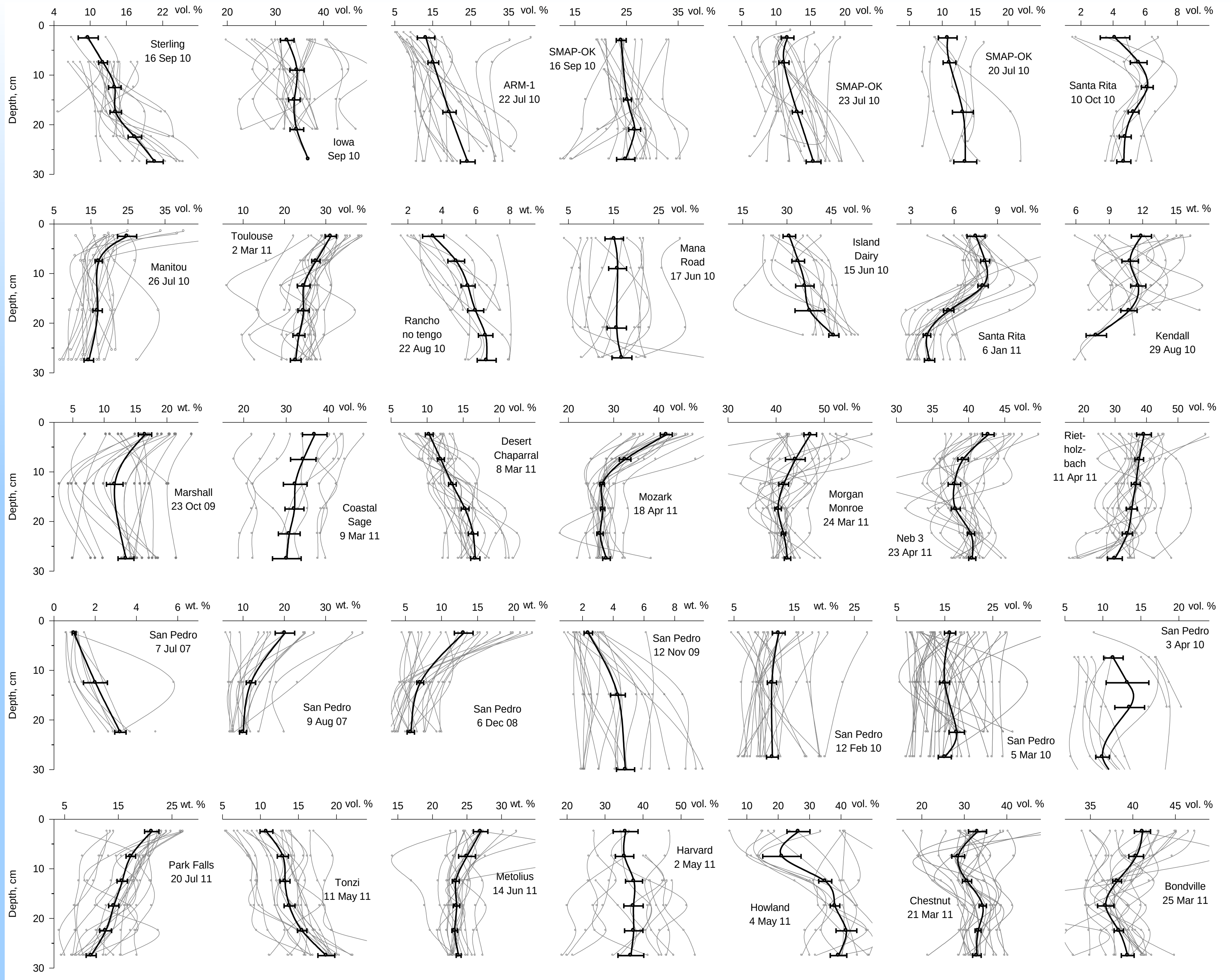
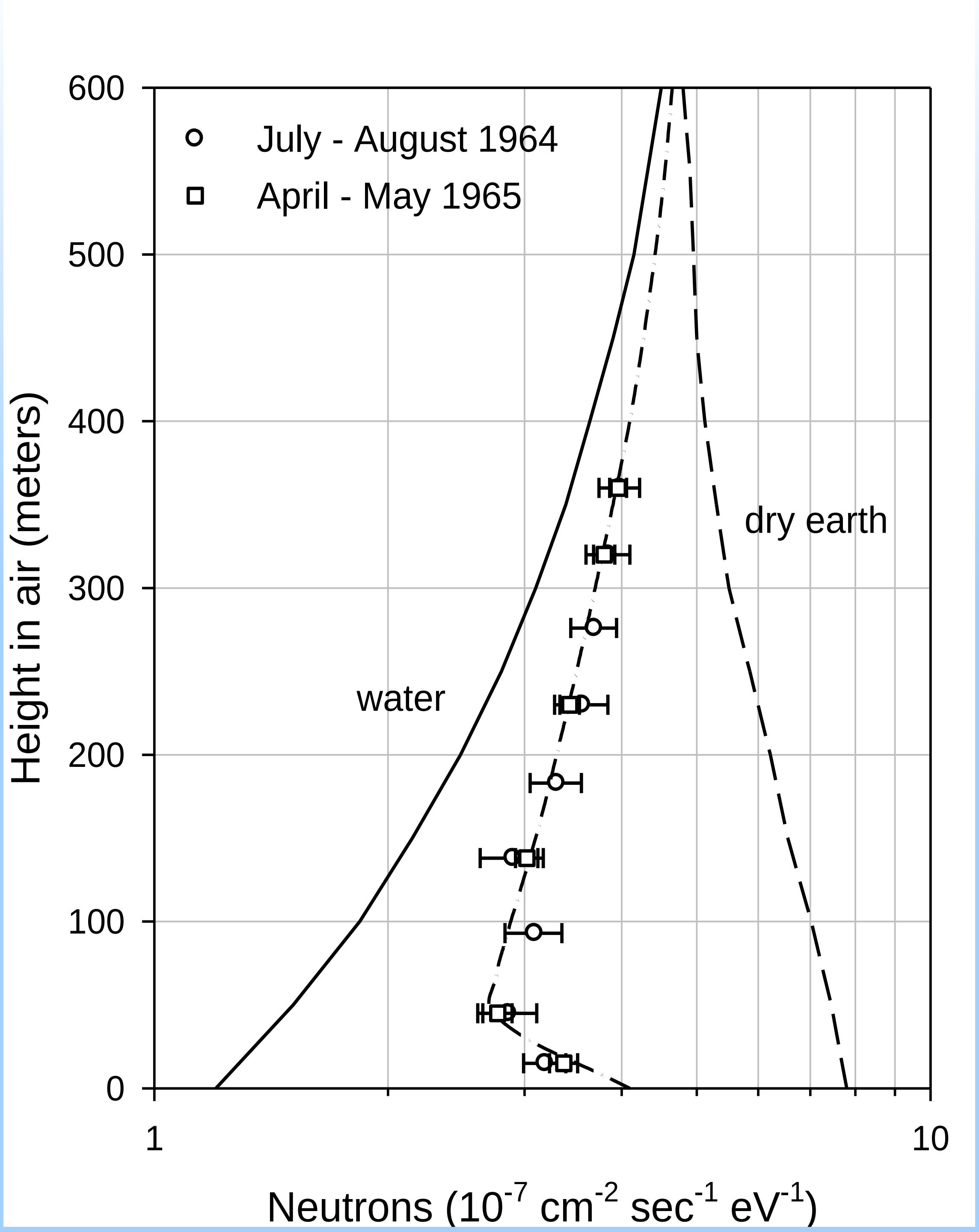
Variations in Soil Moisture

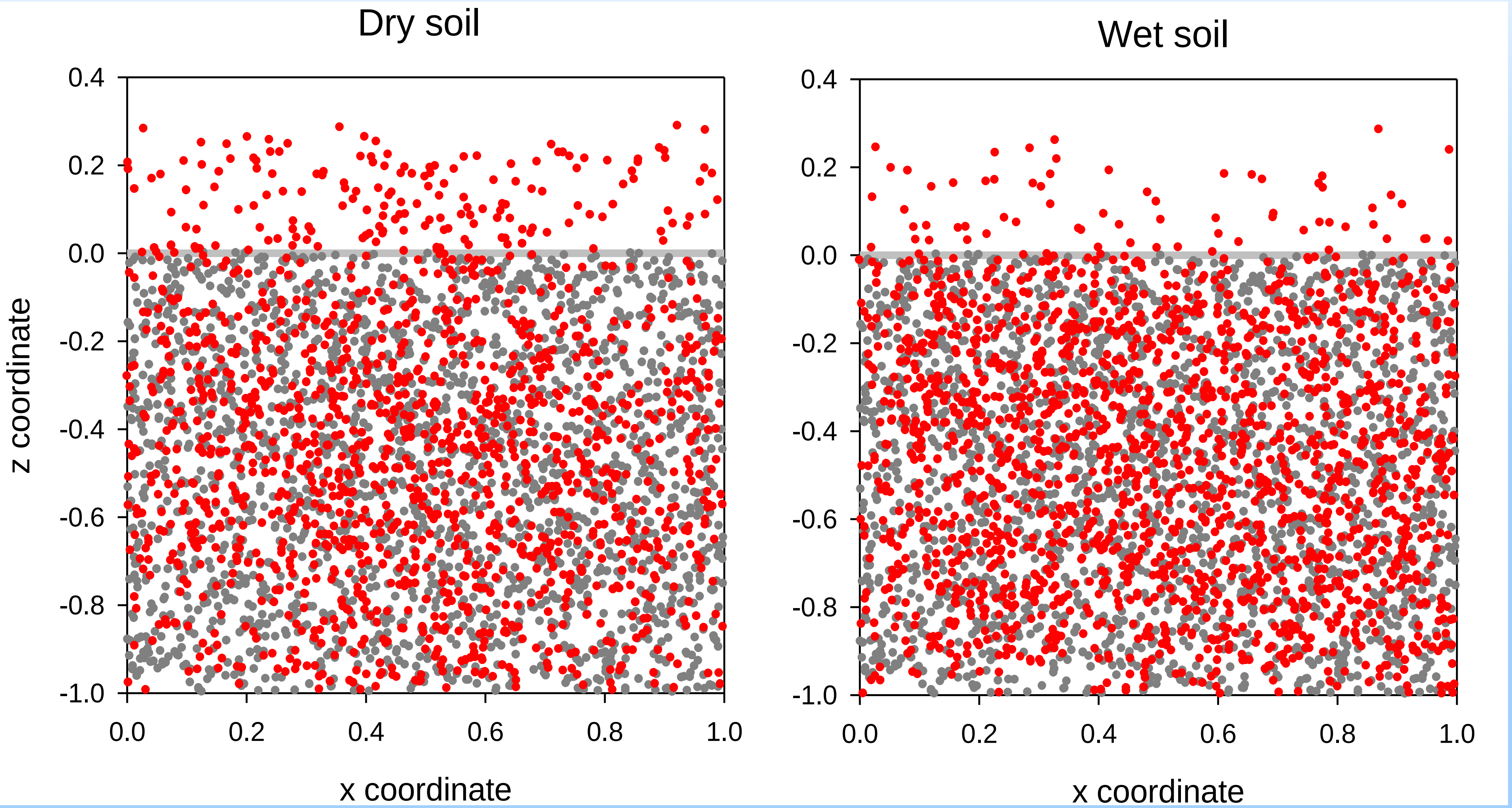


Cosmic-ray Neutrons Above the Surface

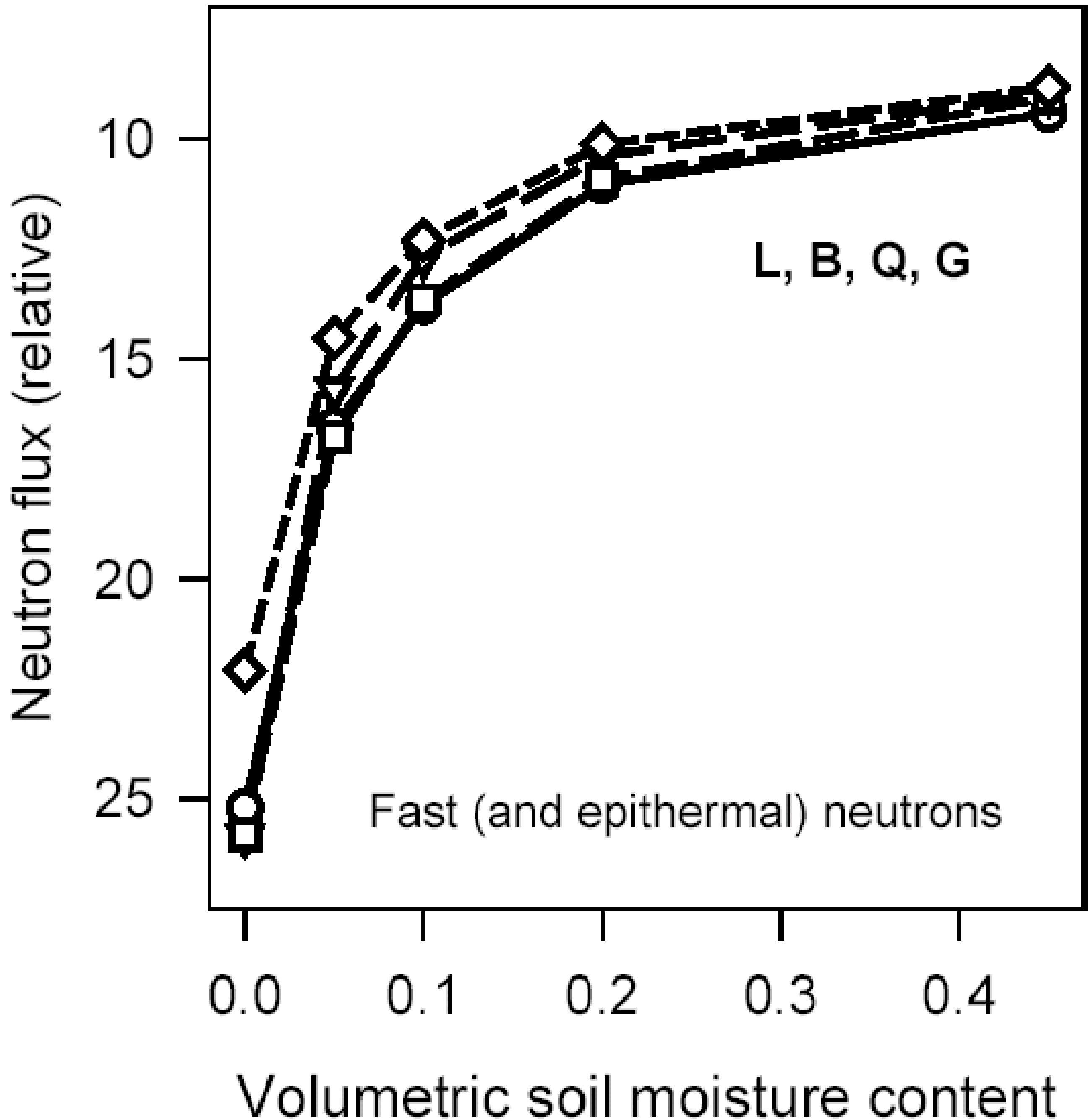


Hendrick, 1966

Effect of Hydrogen on Slowing Fast Neutrons

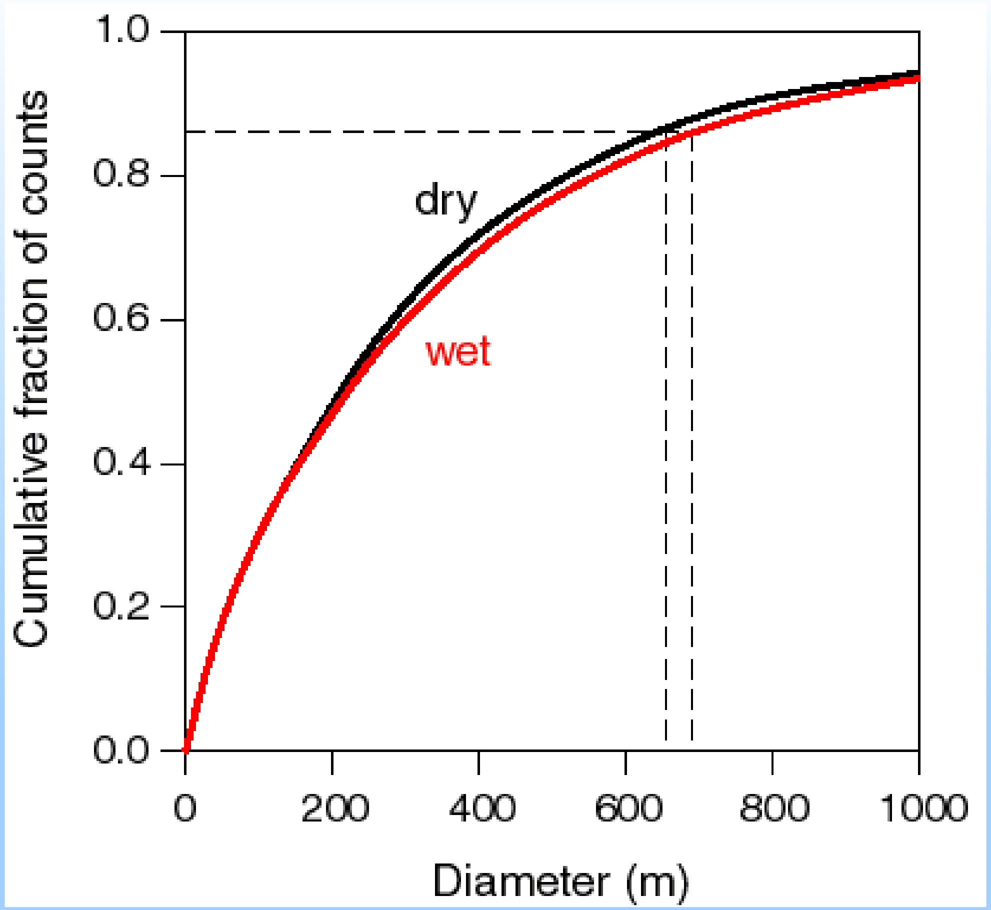


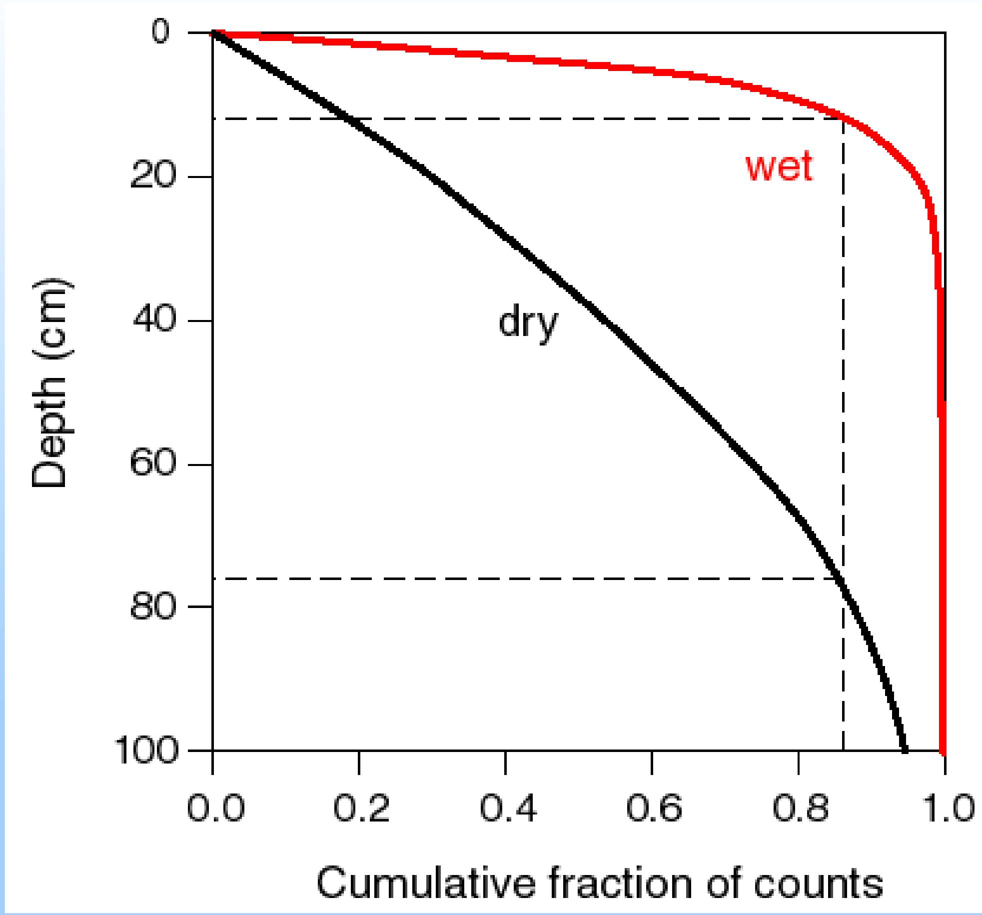
Neutron Response to Soil Moisture



Zreda 2008

Defining the Support Volume





86% of neutrons from within 335 m radius in dry air at sea level

Increases with increasing altitude (decreasing pressure)

86% of neutrons from within a depth of 70 cm (dry)

Depth decreases to 12 cm in wet soils

Independent of altitude (and pressure)

Zreda, 2008

Stationary Measurements

THE UNIVERSITY OF ARIZONA.

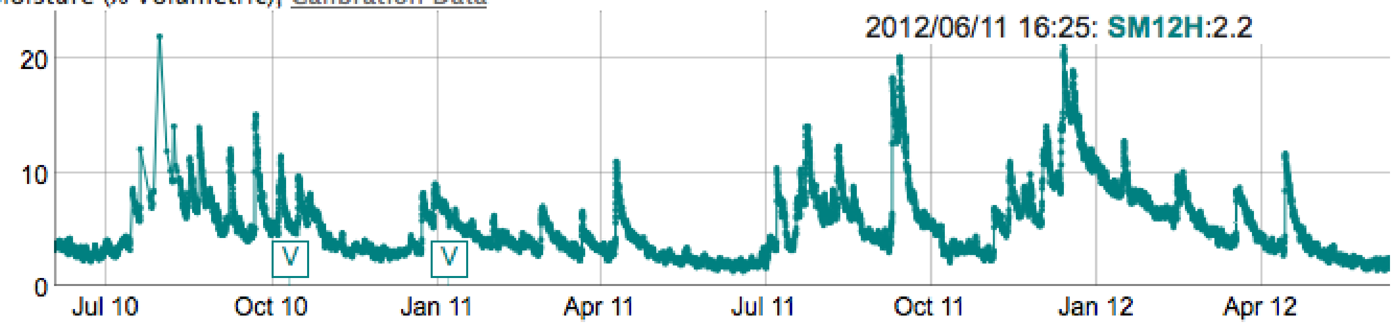
Santa Rita Creosote

Larger Photo Approx Footprint

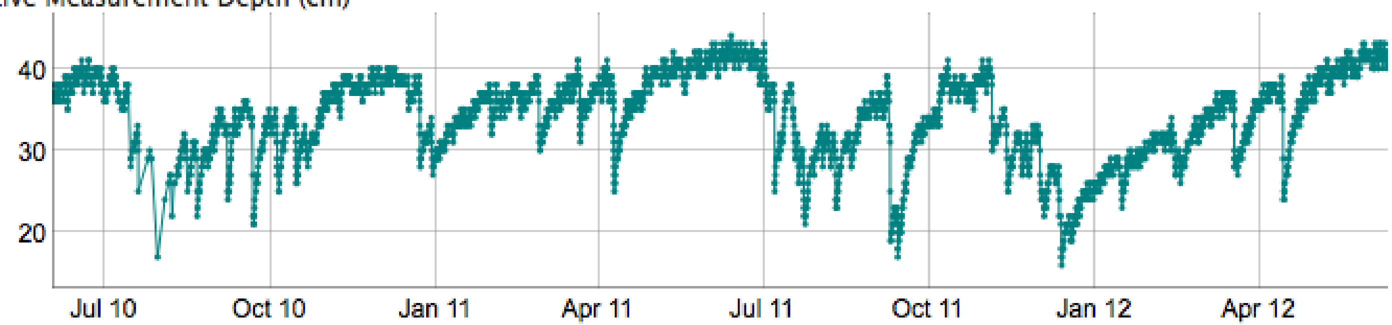
The site is located in Creosote dominated shrubland. A flux tower and several TDR probes are located close to the probe. Please email Trenton Franz at tfranz@email.arizona.edu for the raw TDT and rainfall data files. Summary rainfall and TDT data available from July 2011 to January 2012 here.

Installation Date:	2010-06-02
Timezone (UTC):	-7
Cutoff Rigidity (GV):	5.21
Mean Pressure (mb):	900
Mean Bulk Density (g/cm^3):	1.46
Mean Lattice Water (% weight):	2.50
Max Count Rate (/hr):	3255

Soil Moisture (% Volumetric), Calibration Data



Effective Measurement Depth (cm)



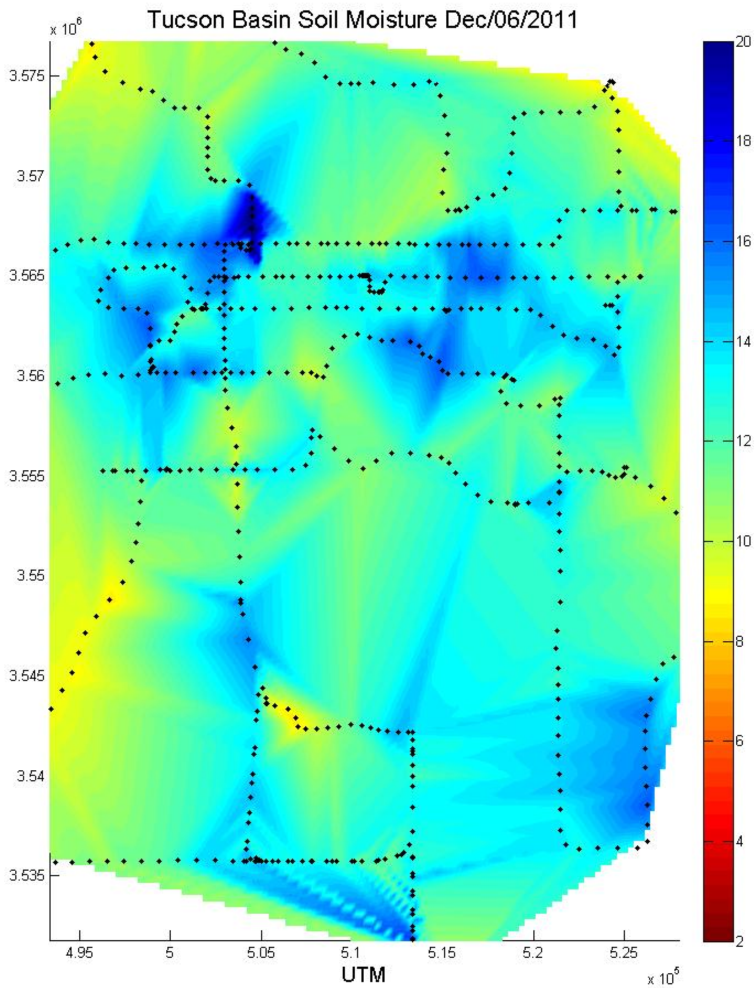
Level 1 Data (Plots) Level 2 Data Level 3 Data Data Levels Excel (.xls) Matlab (.mat) Python (.pkl)

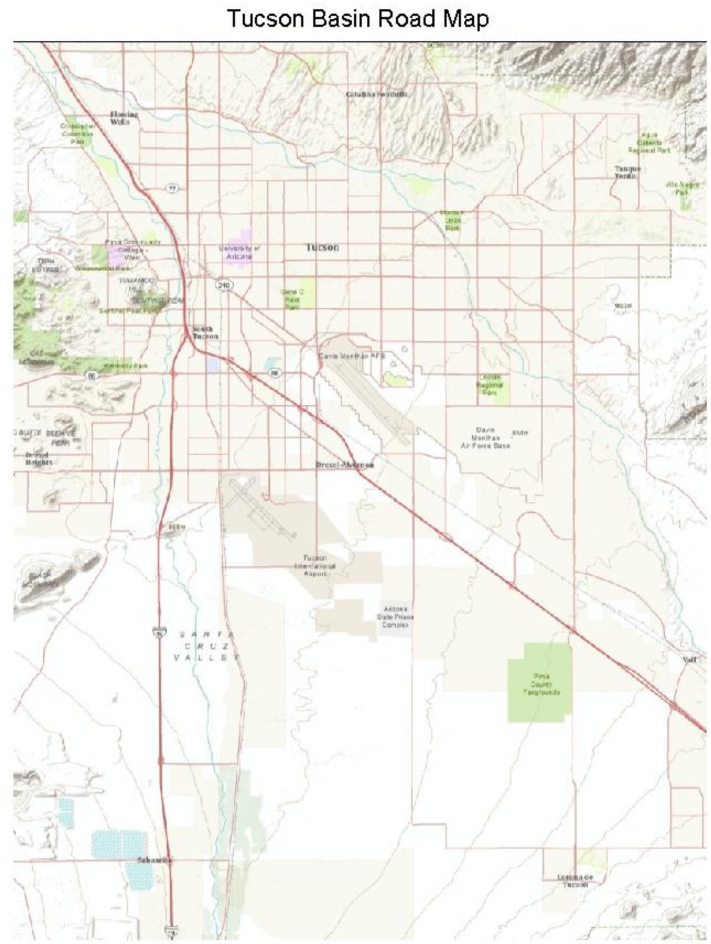
Mobile Measurements

Standard (US) version

Images courtesy of D. Desilets

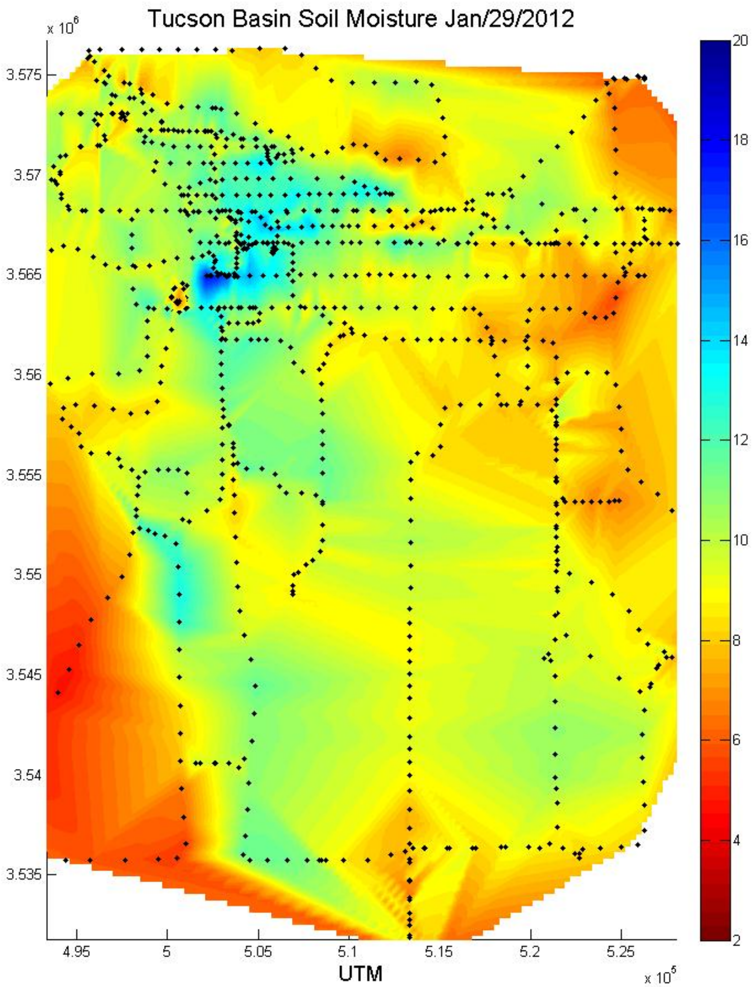
Tucson Basin

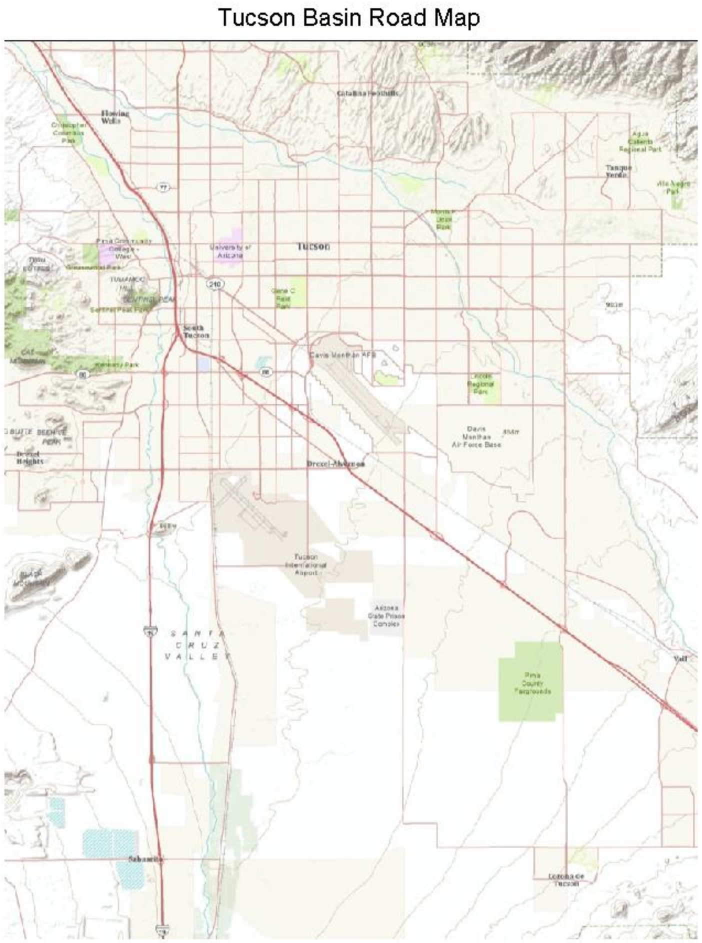




Images courtesy of B. Chrisman

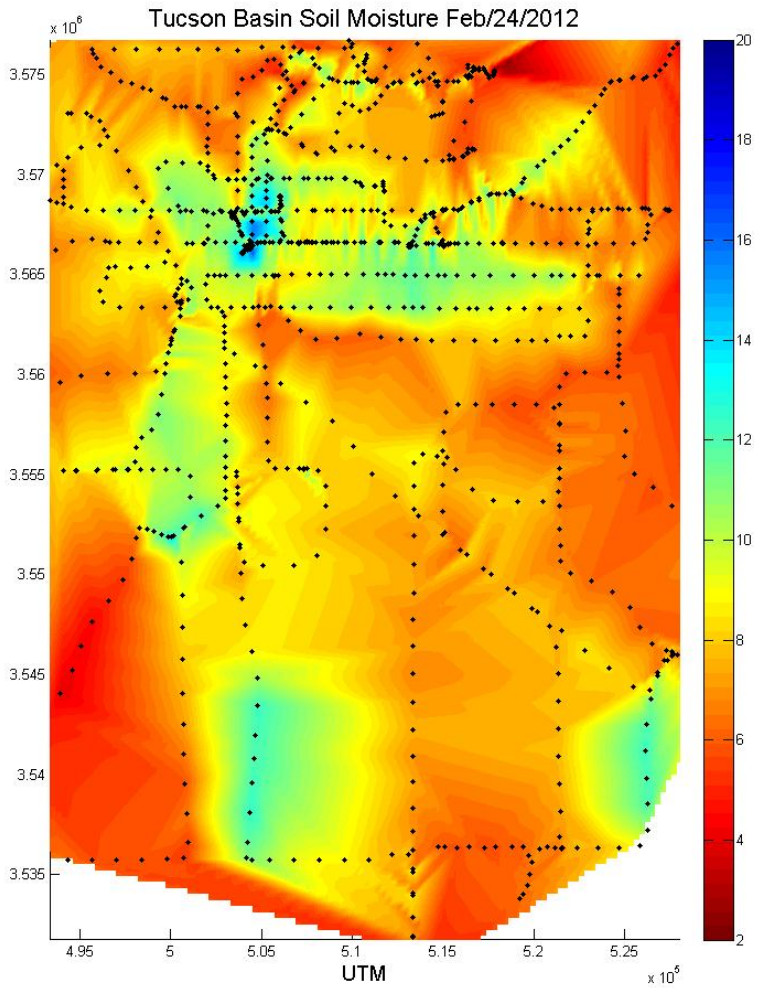
Tucson Basin

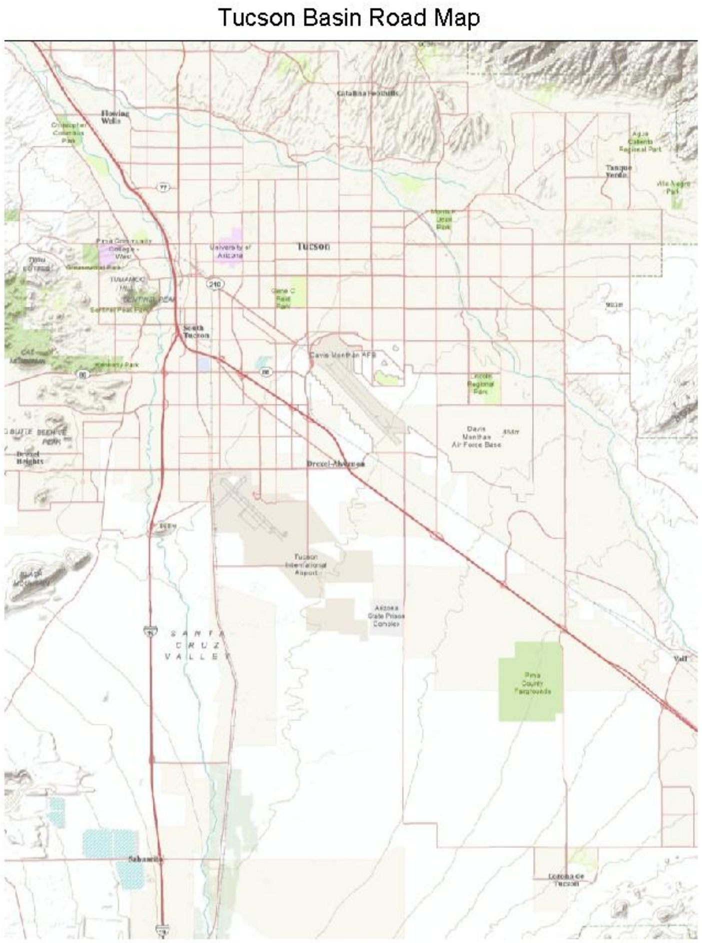




Images courtesy of B. Chrisman

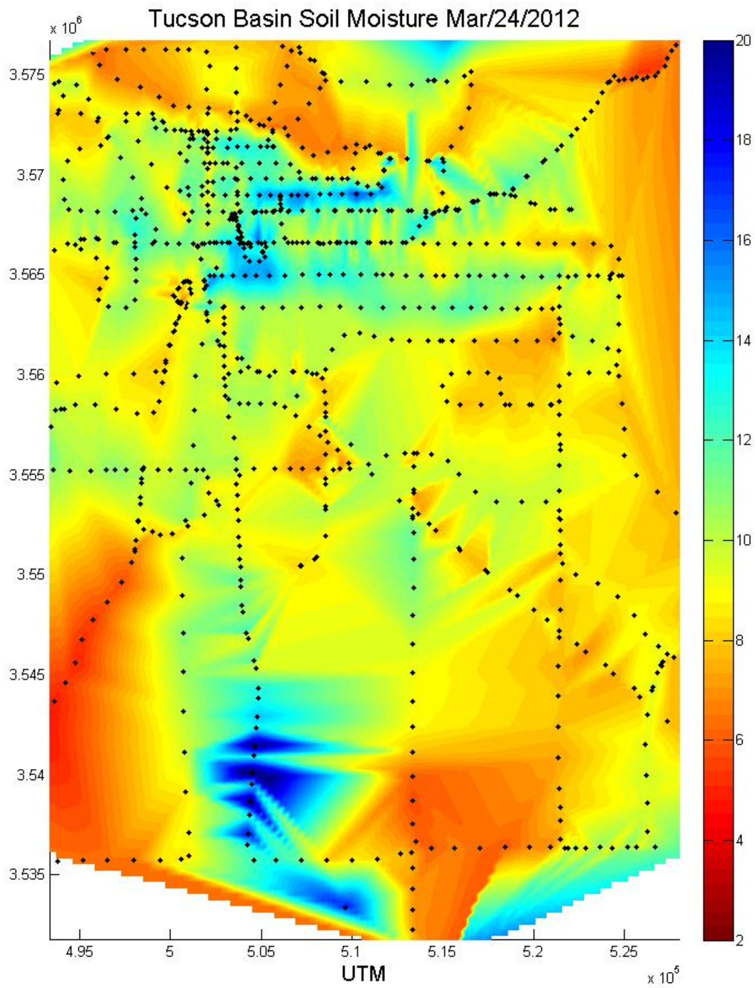
Tucson Basin

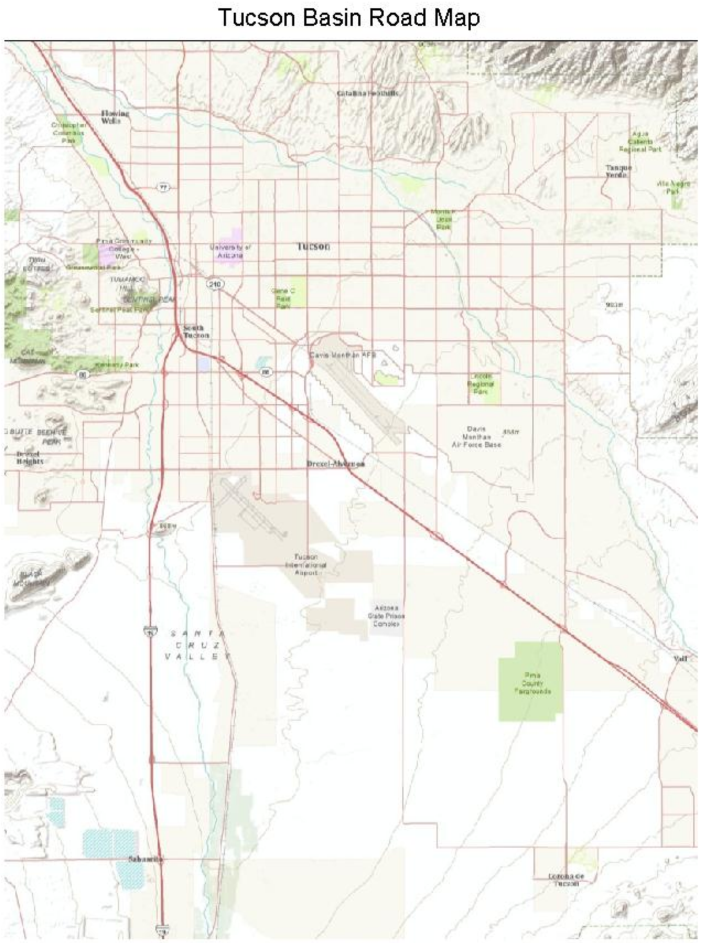




Images courtesy of B. Chrisman

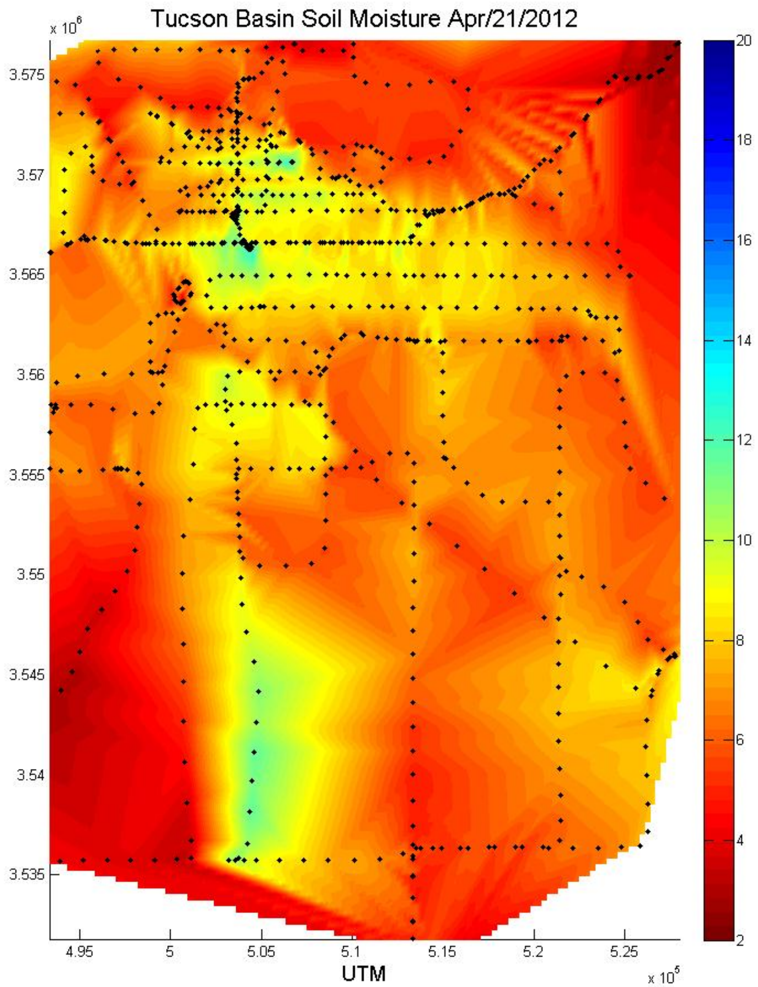
Tucson Basin

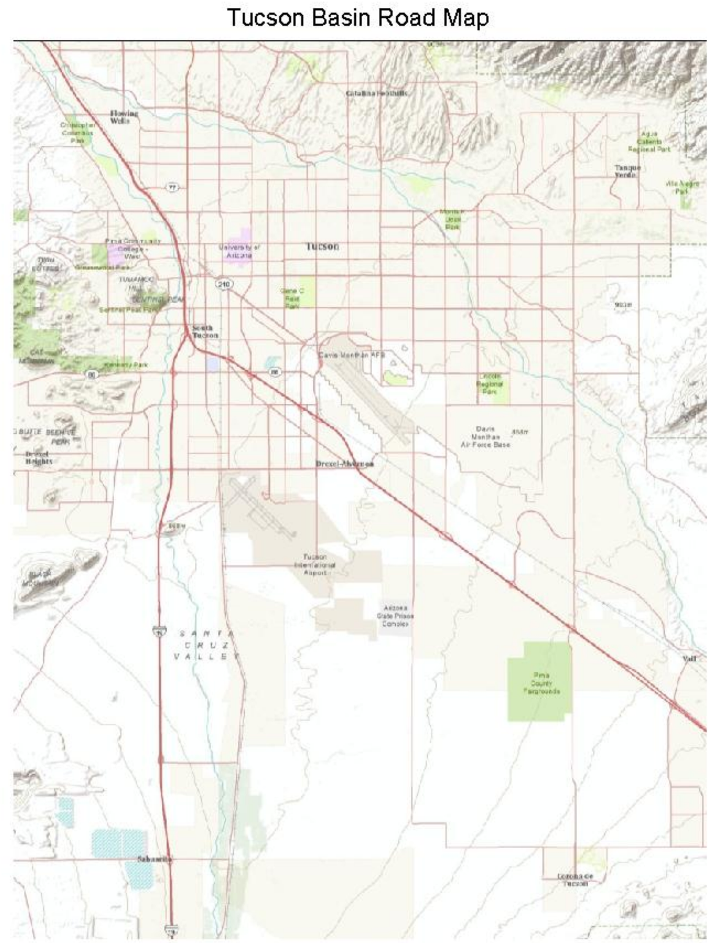




Images courtesy of B. Chrisman

Tucson Basin





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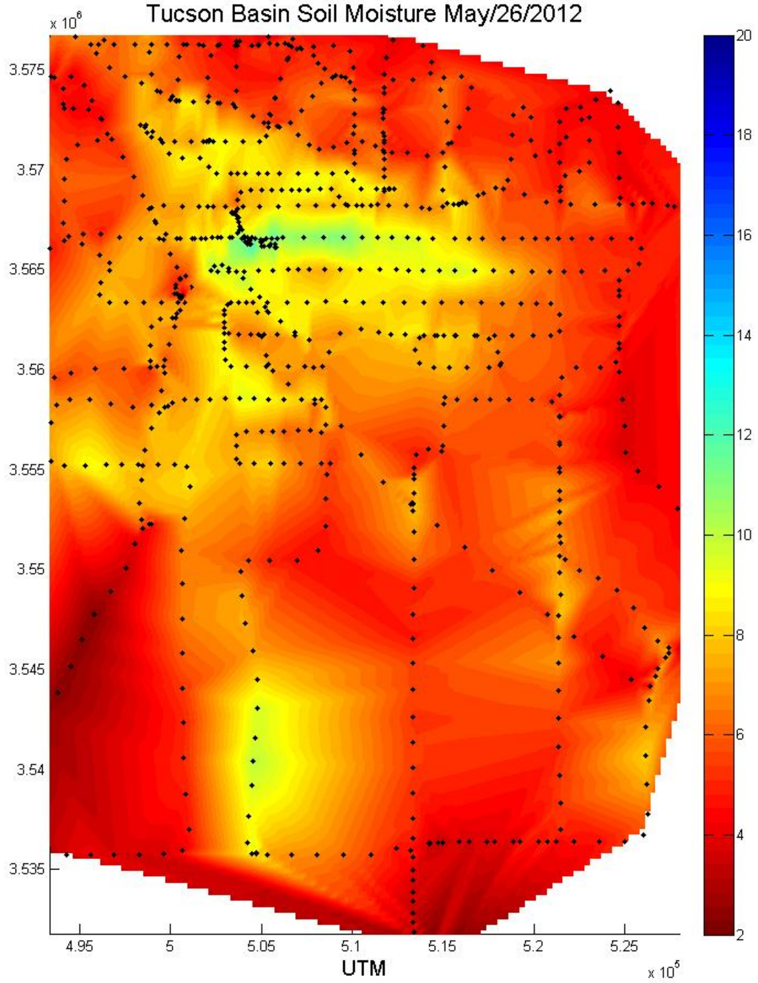
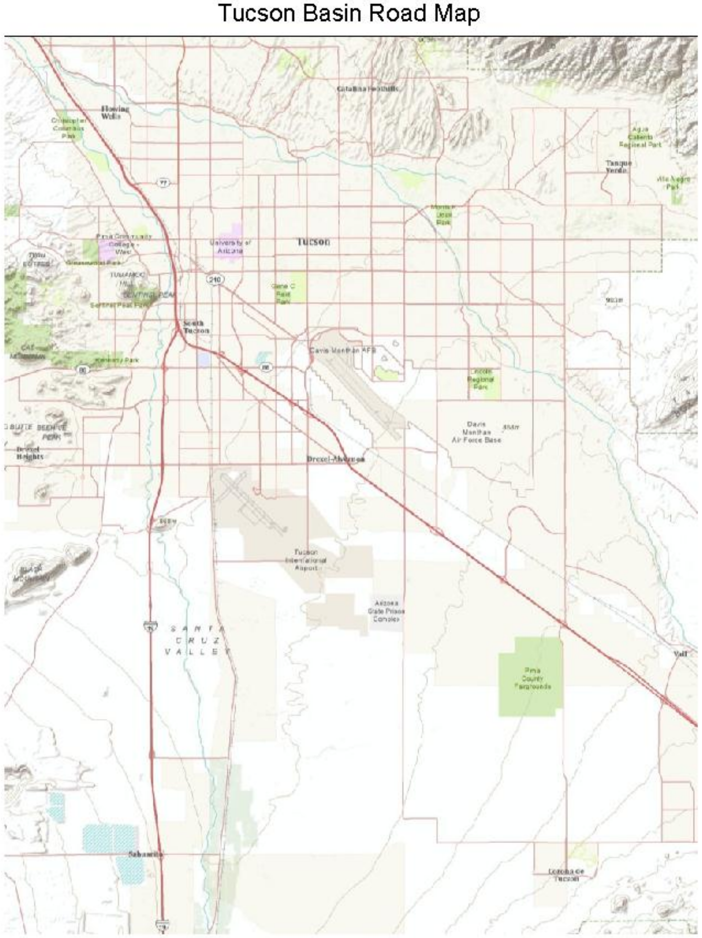
Tucson Basin





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