Arizona Climate
An Overview for the Master Watershed Steward Program

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Overview

- Intro to Climatology
- Climatic Controls
- Regional Climate Variability and ENSO
- Climate Monitoring and Forecasts
Climatology

“Climate is what you expect, weather is what you get.”
- Robert Heinlein

- Climatology: analyzes long-term weather patterns over time or space.
- Climate is a strong determinant of where major ecosystems are found.
- Climate Components
  - insolation
  - temperature
  - air pressure
  - air masses
  - precipitation
Average Arizona Temperatures

• Inland, continental location
• Subtropical high position
• Governed by elevation

Map from http://www.daymet.org
Elevation and Climate

Tucson: 2560 ft.

Palisades: 7960 ft.
Average Arizona Precipitation
Seasonal Distribution of Precipitation

• More winter precip in northern AZ
• Stronger monsoon signal in southeast AZ (more summer precip)

(graphic from Sheppard, et al. 2000)
Fig. 6. Winter flow patterns drawn from circulation patterns at the 700 mb geopotential height, which relates well to the climate over North America (Jorgensen et al. 1957)
North American Monsoon
Monsoon

Monsoon start dates for Tucson
• Average start July 3rd
• Earliest start June 17, 2000
• Latest start July 25, 1987

Monsoon season rainfall (June 15th to September 30th)
• Average monsoon season rainfall 6.06”
• Driest monsoon season 1.59” in 1924
• Wettest monsoon season 13.84” in 1964
Monsoon Dynamics

From Adams & Comrie 1997
Satellite View of Monsoon

June  | July  | August

• Colors indicate cloud top heights (reds: high, greens: low)
• Higher the clouds, the more intense the convection
Climate Variability and ENSO
What are El Nino and La Nina?
Atmosphere-Ocean Coupling
Atmosphere-Ocean Coupling

El Niño Conditions

Equator

Thermocline

120°E  80°W
Atmosphere-Ocean Coupling
Sea Surface Height
Local ENSO Connection

Arizona statewide October thru March Precipitation
(versus Southern Oscillation Index for prior June - November)

Years used
1933/34 - 1996/97

Correlation
= -0.54

20.23 cm / 7.97"
16.28 cm / 6.41"
(all)
11.22 cm / 4.42"

Western Regional Climate Center
El Nino Comparisons

Multivariate ENSO Index for the 7 strongest El Niño events since 1950 vs. current conditions

Update: 5 February 2003
NOAA-CIRES Climate Diagnostics Center (CDC), University of Colorado at Boulder

(From http://www.cdc.noaa.gov/)
Dominant Circulation Pattern: La Nina Winter

Climate Prediction Center/NCEP/NWS
Dominant Circulation Pattern: El Niño Winter

El Niño

LOW PRESSURE

Warm

POLAR JET STREAM

Dry

Wet

Coast

PERSISTENT EXTENDED PACIFIC JET STREAM & AMPLIFIED STORM TRACK
Pacific Decadal Oscillation

<table>
<thead>
<tr>
<th>Period</th>
<th>North Pacific SSTs</th>
<th>Southwest Winters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920s-1940s</td>
<td>Cold</td>
<td>Wetter</td>
</tr>
<tr>
<td>1940s-1970s</td>
<td>Warm</td>
<td>Drier</td>
</tr>
<tr>
<td>1970s-1990s</td>
<td>Cold</td>
<td>Wetter</td>
</tr>
<tr>
<td>1995-present</td>
<td>Warm</td>
<td>Drier?</td>
</tr>
</tbody>
</table>

(from Pagano 1999)

(from http://tao.atmos.washington.edu/pdo)
Recent Conditions

TAO/TRITON Monthly Data January 2005

SST (°C)

SST and Wind

SST and Wind Anomalies

TAO Project Office/PMEL/NOAA

Jan 19 2005
ENSO Comparison

Multivariate ENSO Index (MEI) for four weak Central Pacific El Niño events since 1976 vs. recent conditions

Standardized Departure

Dec,Jan | Mar,Apr | Jun,Jul | Sep,Oct | Dec,Jan | Mar,Apr | Jun,Jul | Sep,Oct | Dec,Jan

Update: 7 January 2005
NOAA-CIRES Climate Diagnostics Center (CDC), University of Colorado at Boulder
Climate Monitoring and Prediction
**U.S. Drought Monitor**

*January 11, 2005*

**Intensity:**
- Yellow: Abnormally Dry
- Beige: D1 Drought - Moderate
- Brown: D2 Drought - Severe
- Red: D3 Drought - Extreme
- Maroon: D4 Drought - Exceptional

**Drought Impact Types:**
- A: Agricultural (crops, pastures, grasslands)
- H: Hydrological (water)
- (No type): Both impacts

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

[http://drought.unl.edu/dm](http://drought.unl.edu/dm)

*Released Thursday, January 13, 2005*

*Author: Mark Svoboda, NDMC*
Accumulated Precipitation

(from http://www.wrh.noaa.gov/twc)
Standardized Precipitation Index

- Drought index like the Palmer Severity Drought Index
- More responsive to short term changes in precipitation
- Evaluates precip. deviations at different timescales (short-term and long-term)
Palmer Drought Severity Index

(From http://www.cdc.noaa.gov/)
Snowpack

Basin Average Snow Water Content. ( % of Average.)

Percent of Average

- > 200
- 175 to 200
- 150 to 175
- 125 to 150
- 110 to 125
- 90 to 110
- 75 to 90
- 50 to 75
- 25 to 50
- < 25

Report Date:
JANUARY 19, 2005

Provisional Data
Based on Mountain Data from NRCS SNOTEL Sites

Data provided by
Water and Climate Center
National Resource Conservation Service
Portland, Oregon

Western Regional Climate Center
Desert Research Institute
Reno, Nevada

(From http://www.wcc.nrcs.usda.gov/cgibin/westsnow.pl)
Forecasts for this Winter: Dec-Feb ‘05

- Forecasts are based on statistical/dynamical models and expert assessment
- Greater forecast confidence during strong El Nino/La Nina conditions

(From http://www.cpc.noaa.gov)
Climate Change

Figure 12. Temperature trend comparisons between 20th century observation and modeled scenarios of the 21st century. Compiled by: Benjamin Felzer, National Center for Atmospheric Research

Figure 13. Precipitation trend comparisons between 20th century observation and modeled scenarios of the 21st century. Compiled by: Benjamin Felzer, National Center for Atmospheric Research

From: ISPE Southwest Regional Assessment
Key Summary Points

• Southeast AZ and seasonal precip
  – Winter storms and summer monsoon
  – Different mechanisms and variability

• El Nino and La Nina teleconnections with AZ
  – El Nino usually means above normal winter precip (not always consistent)
  – La Nina means below normal
  – PDO?

• Many monitoring products are available on the web; precipitation still difficult to find

• Use climate forecasts carefully
Resources

- Climate Assessment for the Southwest (http://www.ispe.arizona.edu/climas)
- National Weather Service (http://www.weather.gov)
- Climate Prediction Center (http://www.cpc.noaa.gov/)
- Western Regional Climate Center (http://wrcc.dri.edu/)
- National Drought Monitor (http://www.drought.unl.edu/dm/index.html)
- **Climate Science Applications Program** (http://cals.arizona.edu/climate)