Arizona's Land Subsidence Monitoring Program

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CGSIC
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Protecting Arizona's Water Supplies
For Its Next Century


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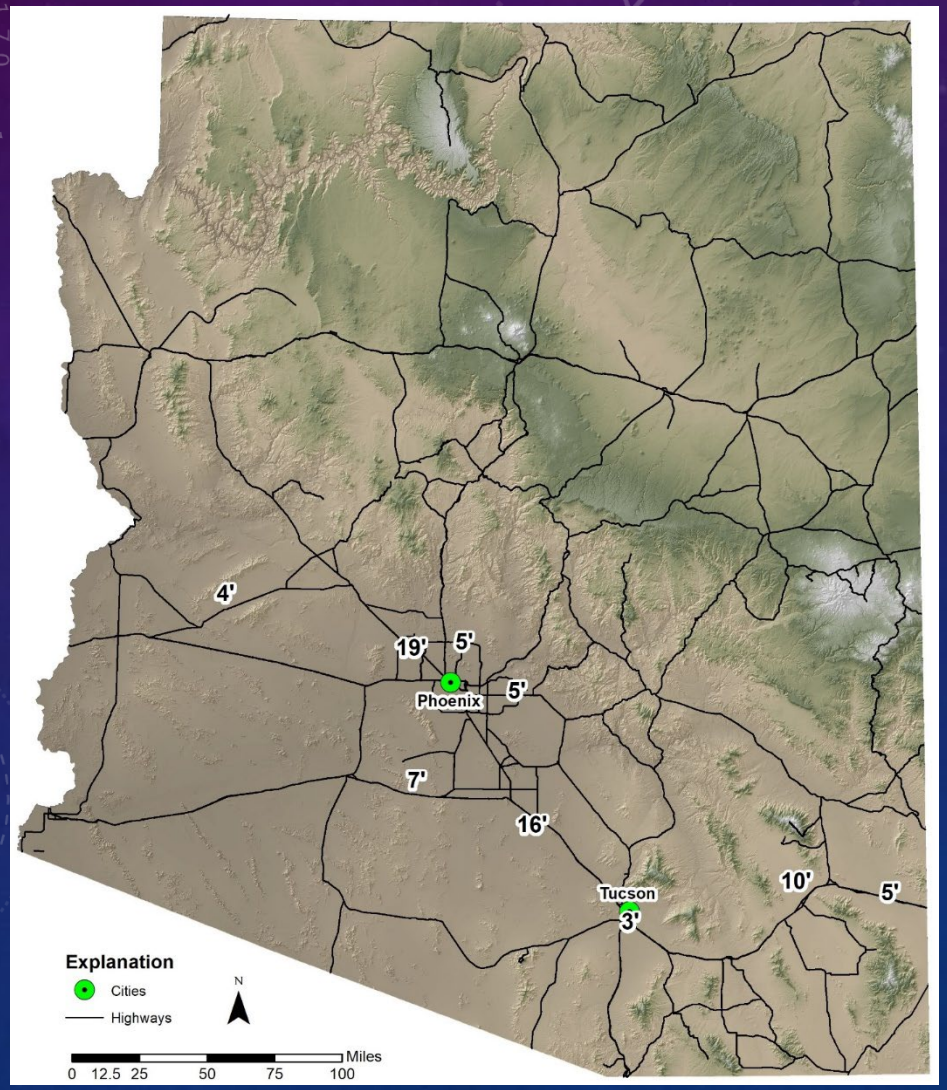
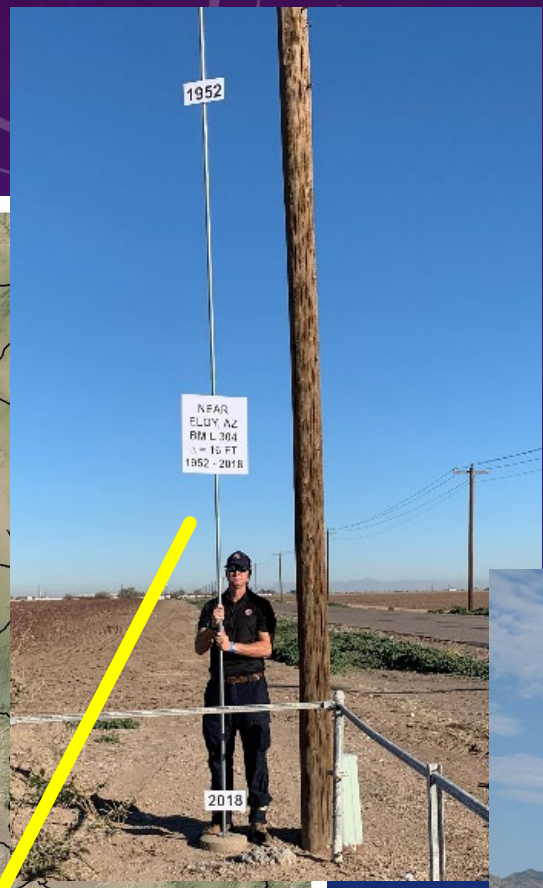
ADWR's Land Subsidence Monitoring Program

- Repeat surveys revealed land subsidence up to 19 feet



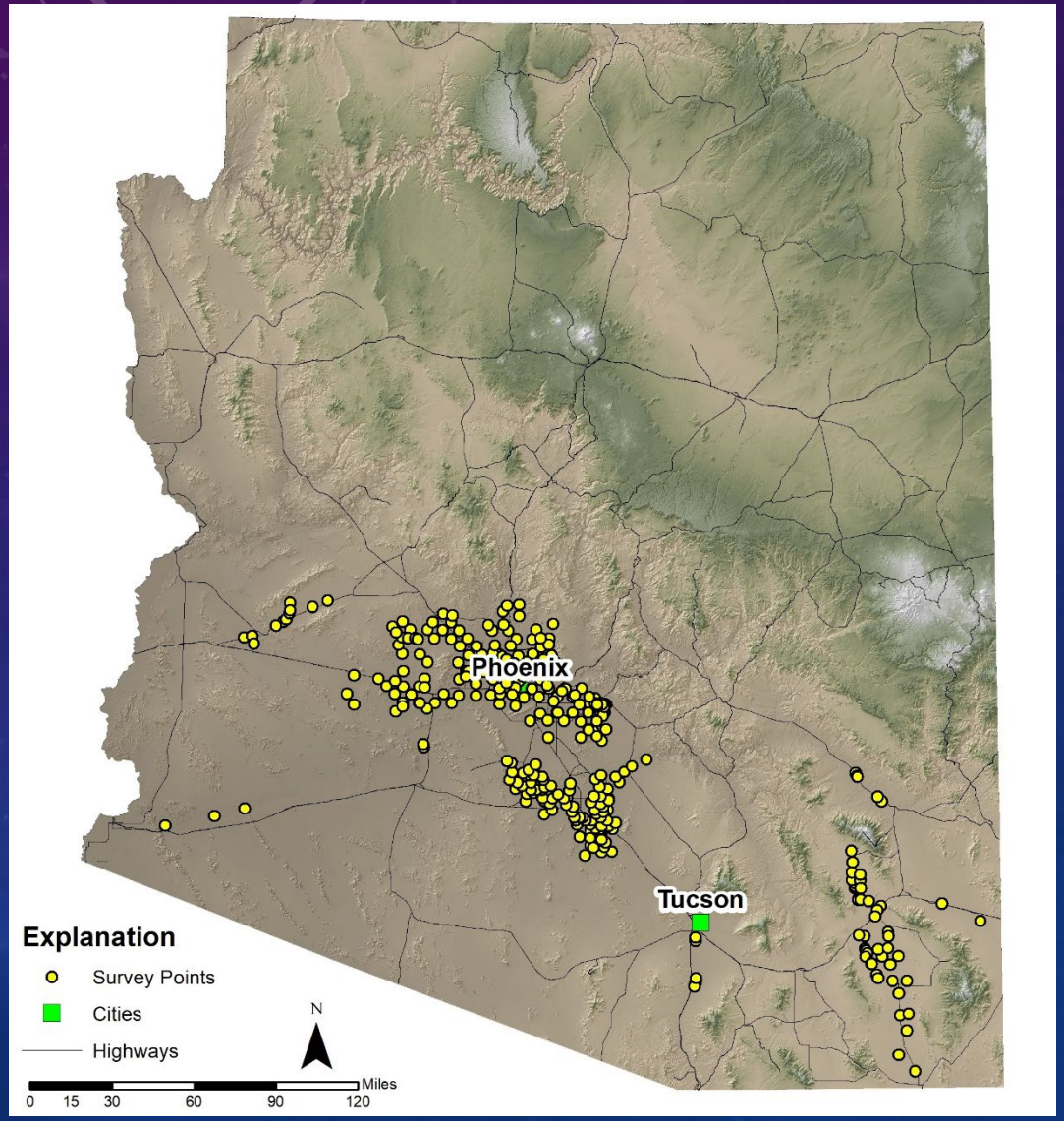
ADWR's Land Subsidence Monitoring Program

- Repeat surveys revealed land subsidence up to 19 feet



ADWR's Land Subsidence Monitoring Program

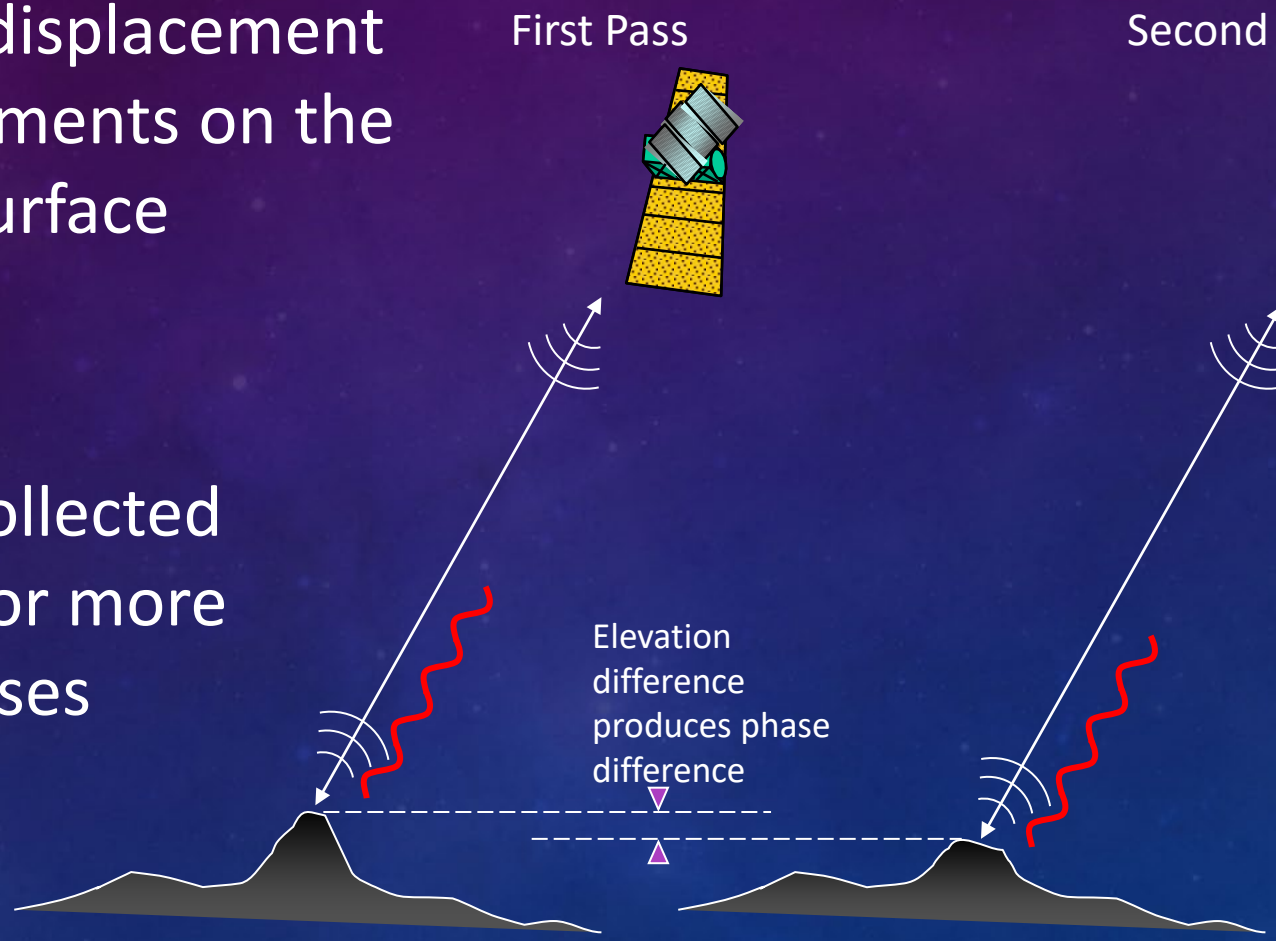
- Have been completing GNSS surveys since 1998
- Data is processed using Trimble Software, NGS OPUS, OPUS-Share, and OPUS Projects
- Networks have been expanded to improve monitoring
- Surveys vary from monthly, seasonally, and annually



Synthetic Aperture Radar Interferometry (InSAR)

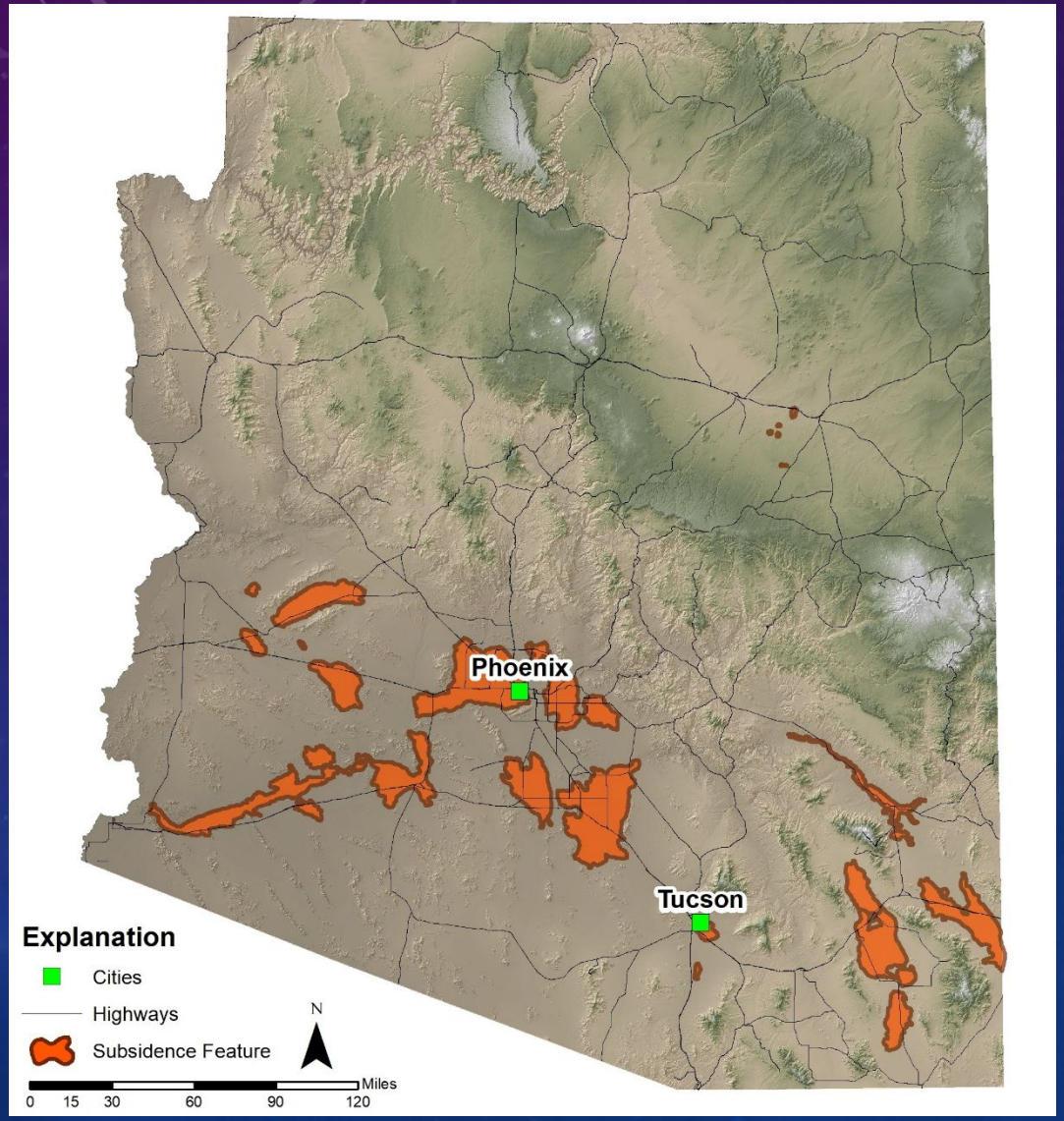
Enables displacement measurements on the Earth's surface

Uses data collected during two or more satellite passes



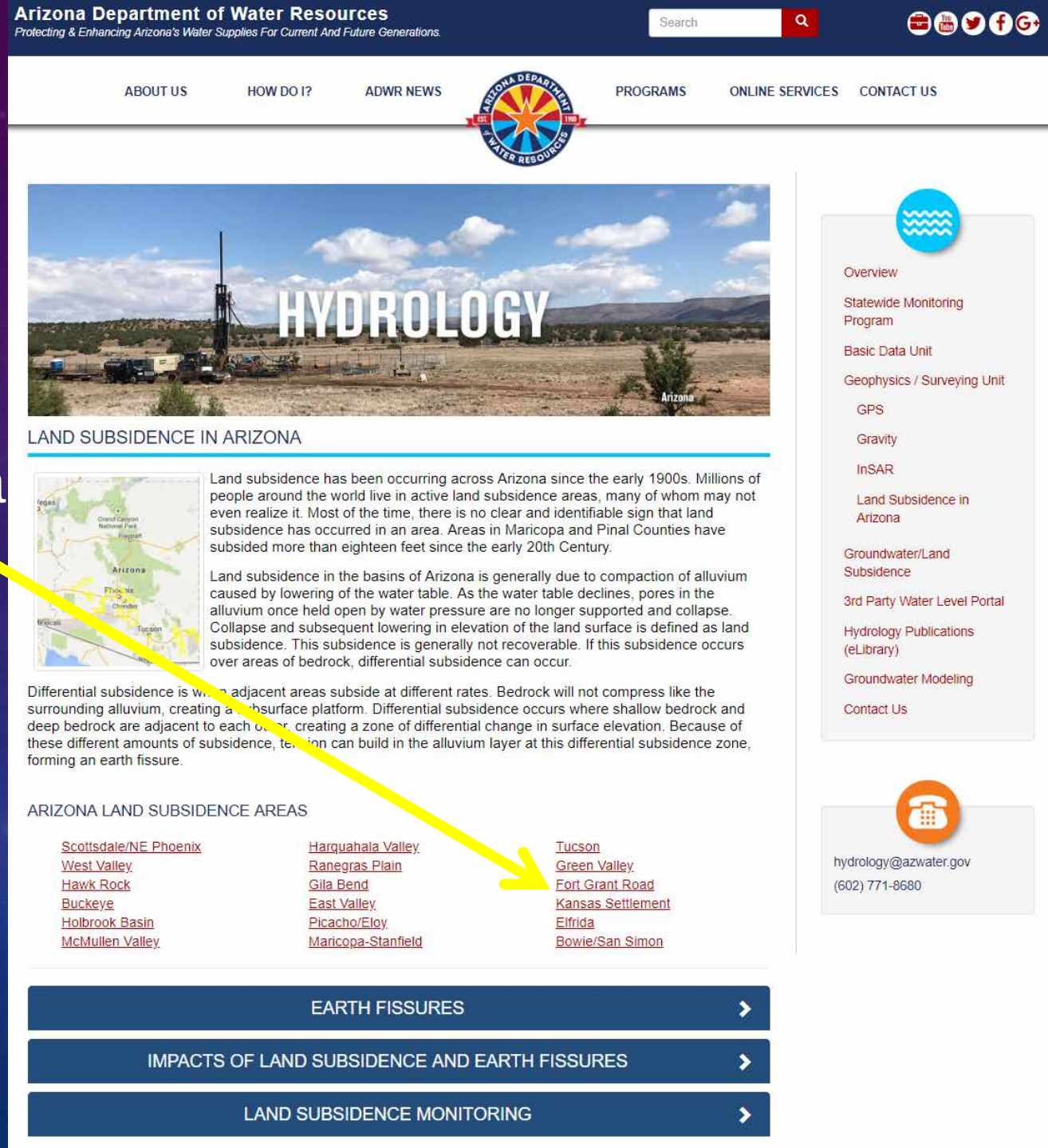
ADWR's Land Subsidence Monitoring Program

- Started in 2002 from a NASA grant
- Have an extensive InSAR library, data between 1992 and present
- By 2022, identified 30 individual land subsidence features covering an area greater than 4,100 square miles
- Cost of the InSAR data has exceeded $2.0 million dollars



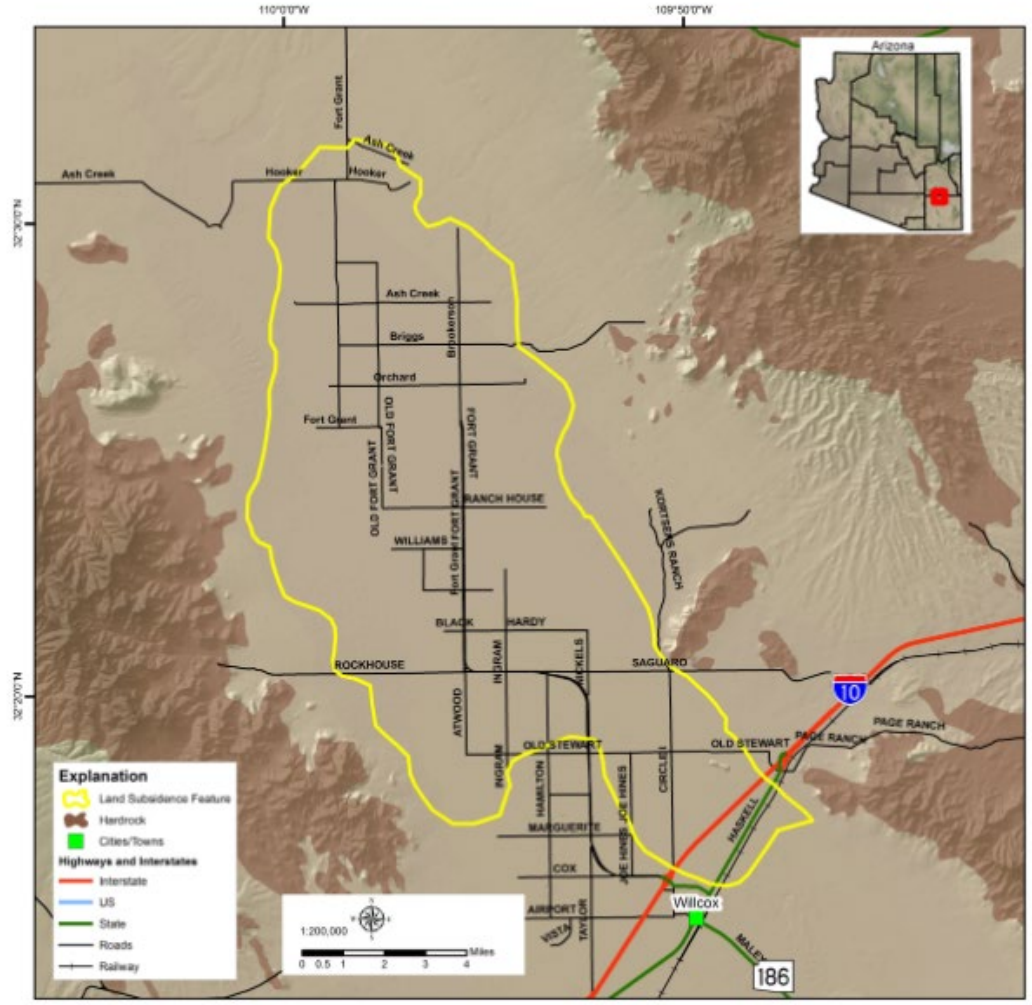
ADWR's Land Subsidence Website

- ADWR's website has a dedicated land subsidence section
- Each land subsidence feature has a dedicated webpage
- A total of 699 land subsidence maps are available for download
- The InSAR-derived maps cover various periods of time between 1992 and 2000, 2004 to 2010, and 2010 to present



ADWR's Land Subsidence Website

- Able to access both land subsidence maps and land subsidence rate maps



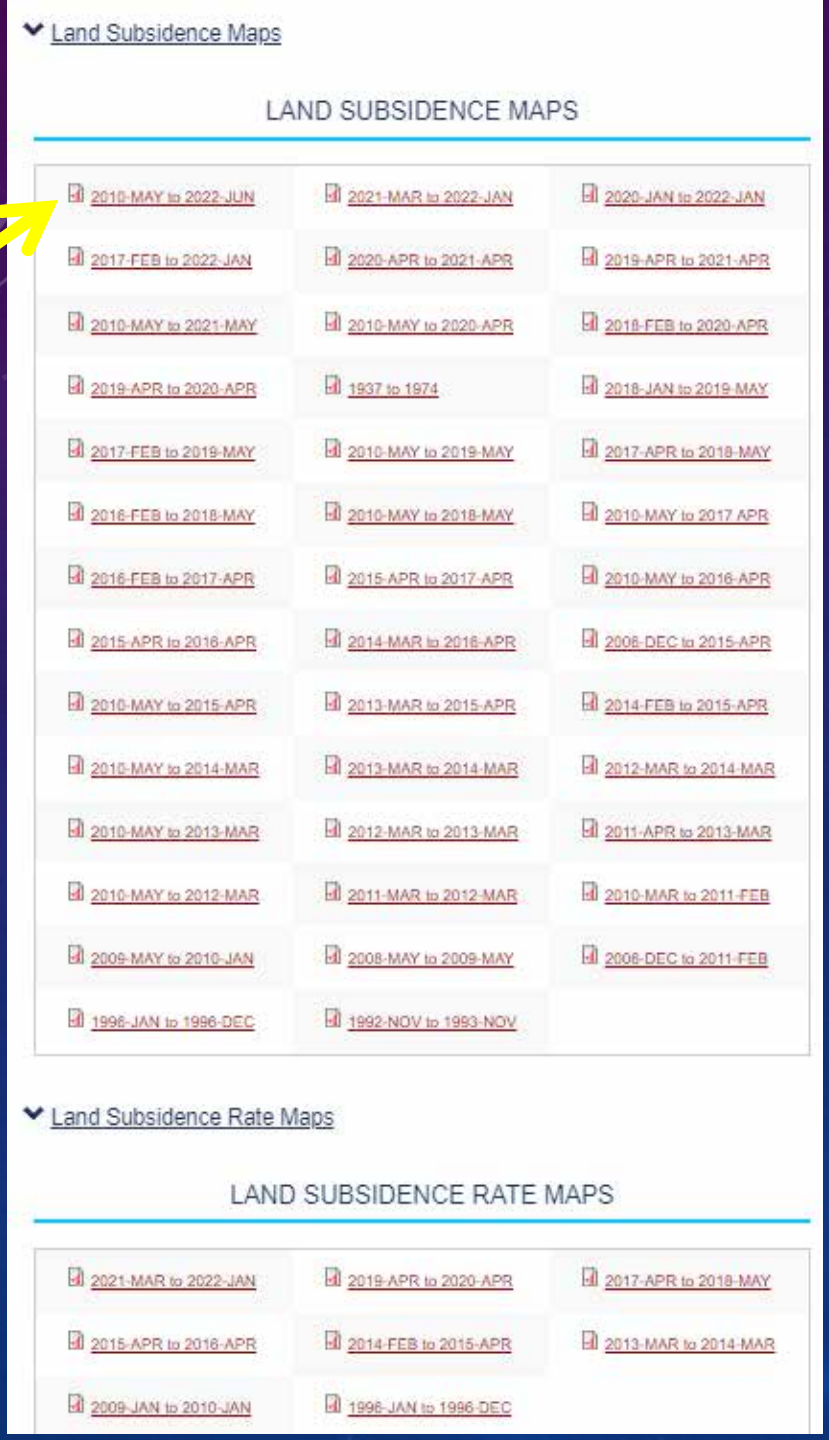
FORT GRANT ROAD LAND SUBSIDENCE

The Fort Grant Road land subsidence feature is located in southeastern Cochise County. Unincorporated State Trust, Bureau of Land Management, and private lands are located within the Fort Grant Road land subsidence feature.

- Land Subsidence Maps
- Land Subsidence Rate Maps

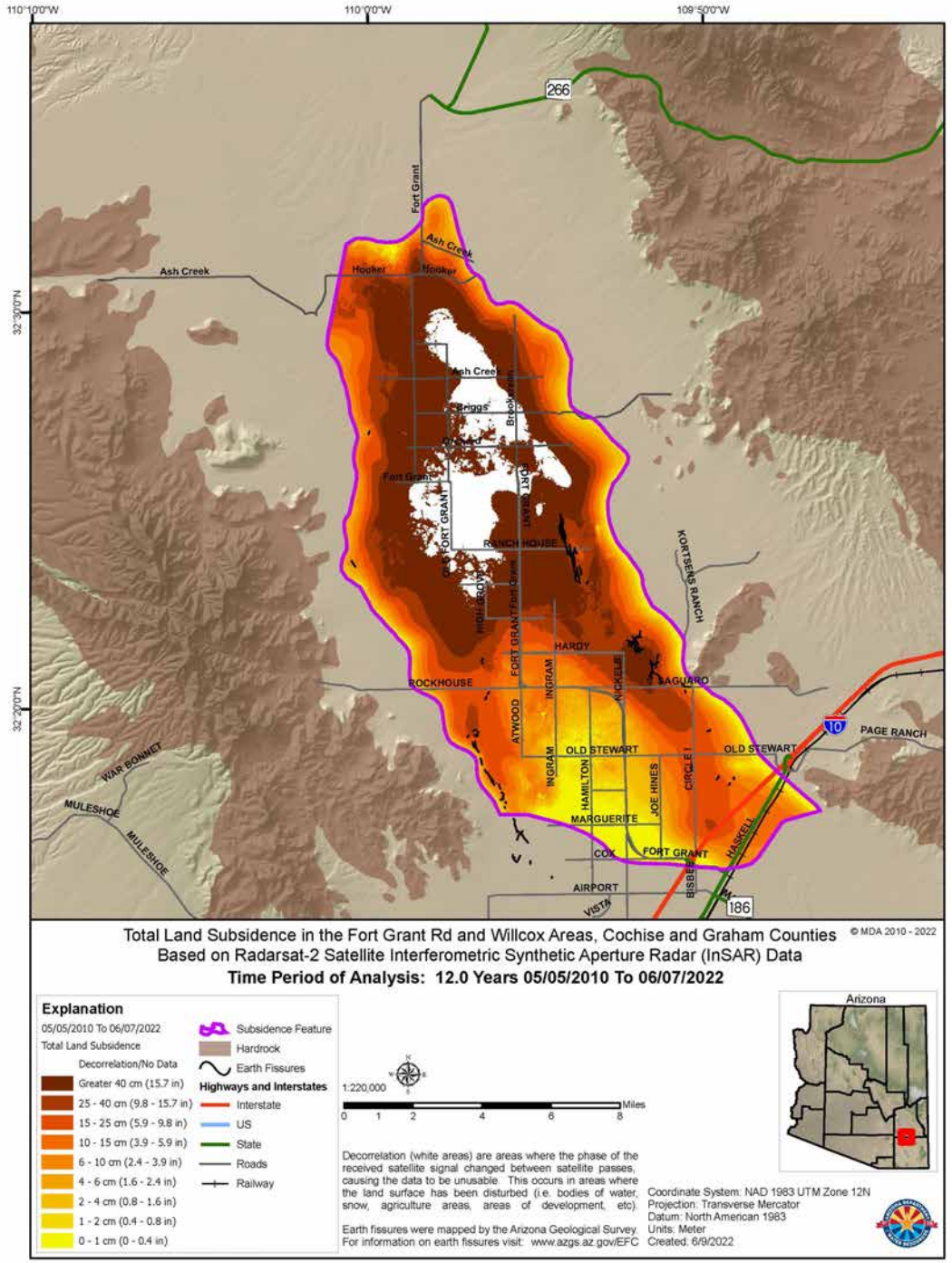
ADWR's Land Subsidence Website

- Clicking any time-period will open up a pdf land subsidence map displaying the magnitude or rate of land subsidence for that time-period



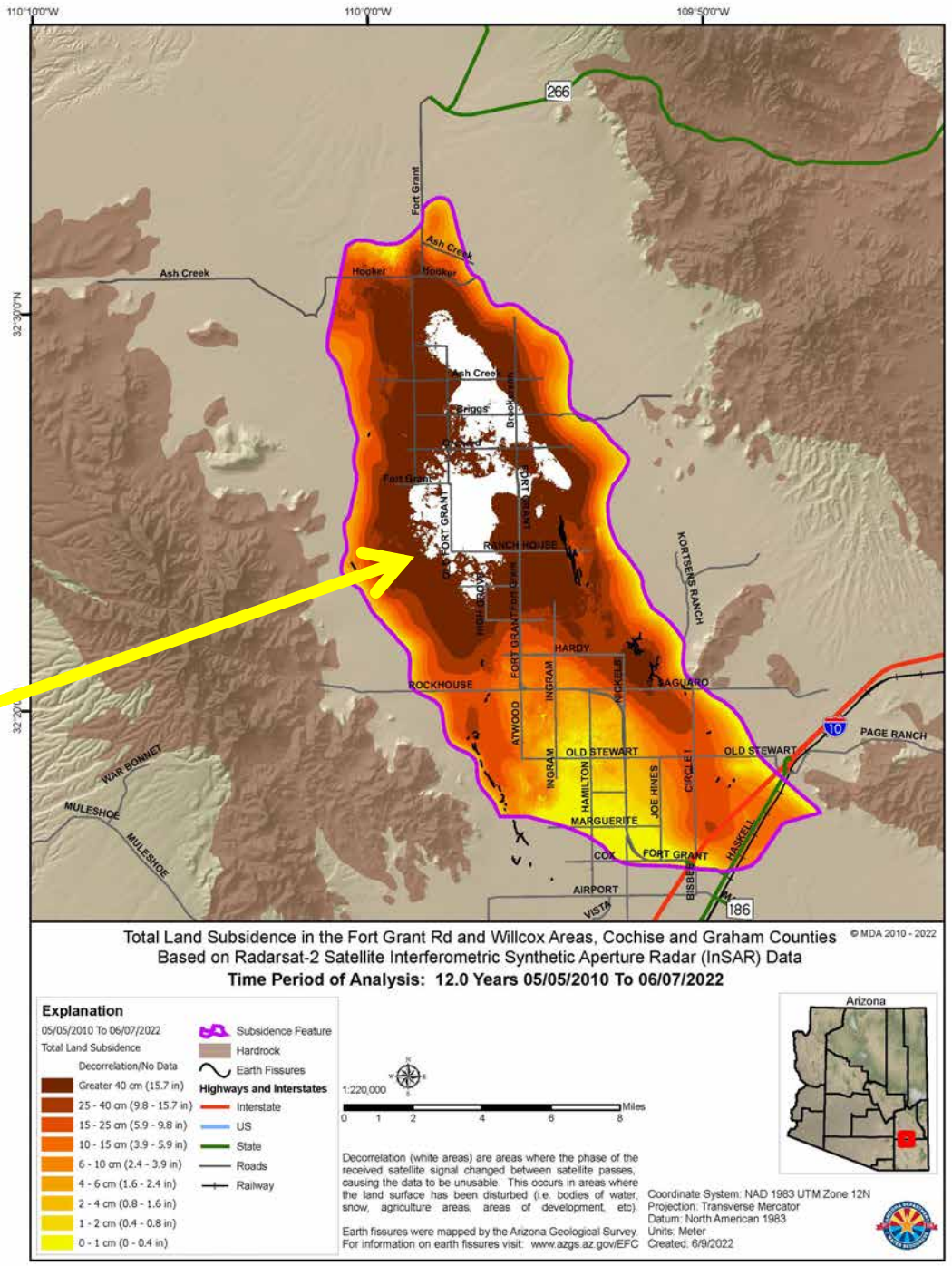
ADWR's Land Subsidence Website

- Land subsidence map for the Fort Grant Rd land subsidence feature in the Willcox Groundwater Basin between May 2010 and June 2022
- Subsidence as high as 137cm (4.5 feet)

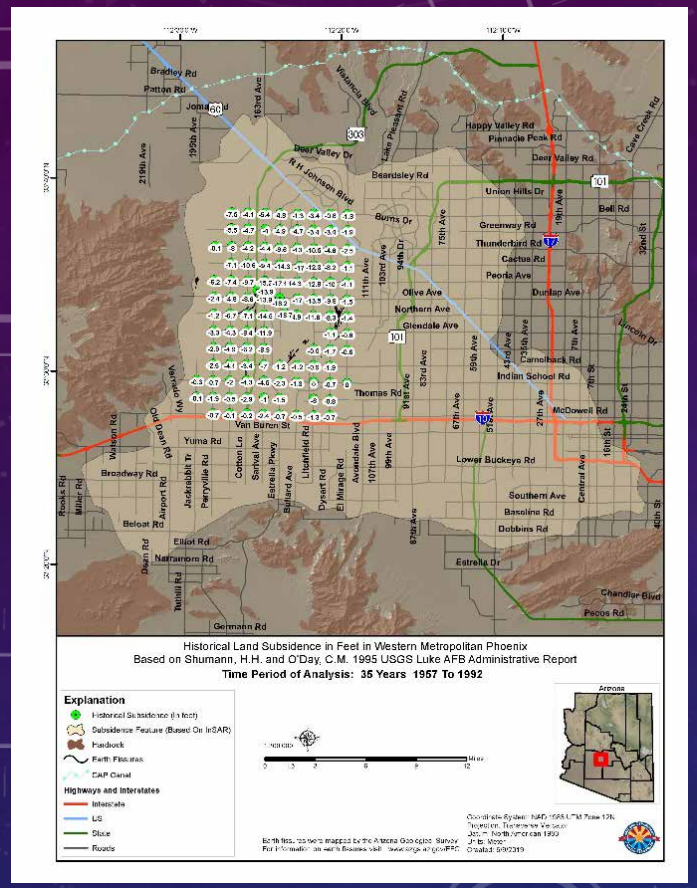


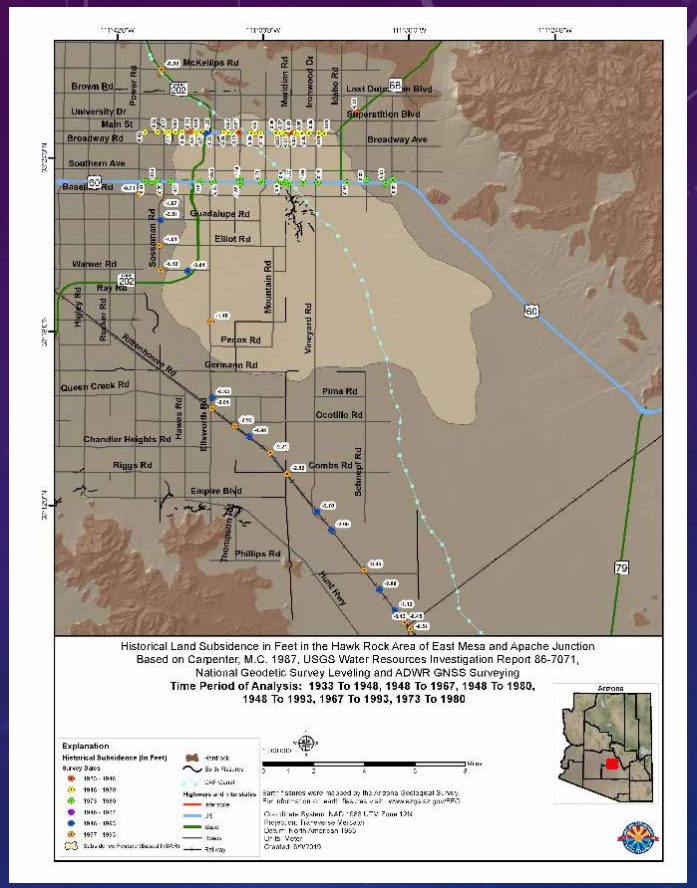
ADWR's Land Subsidence Website

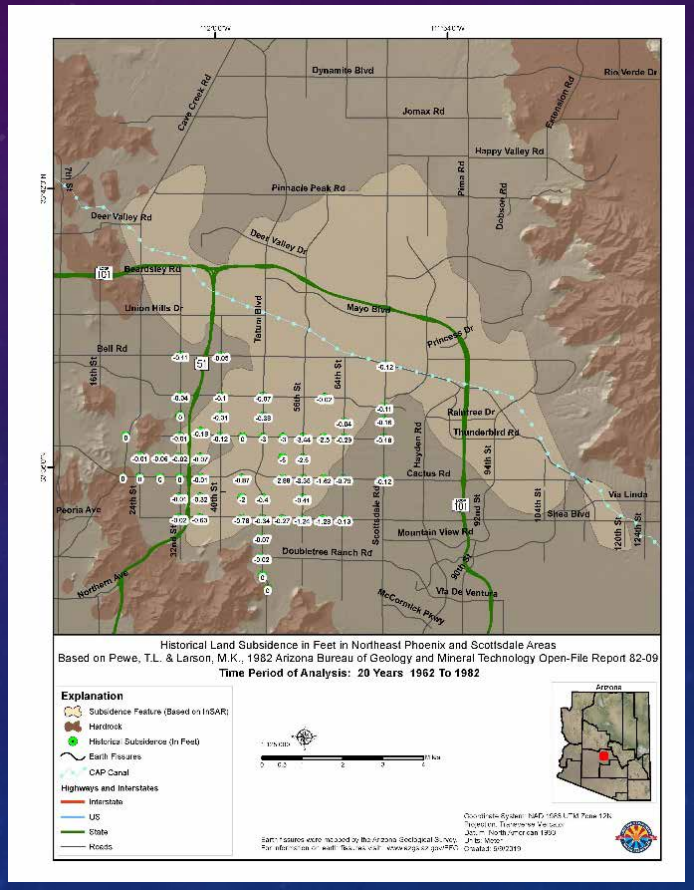
- Subsided over 11 feet between 1969 and 2022



Documenting Historical Land Subsidence

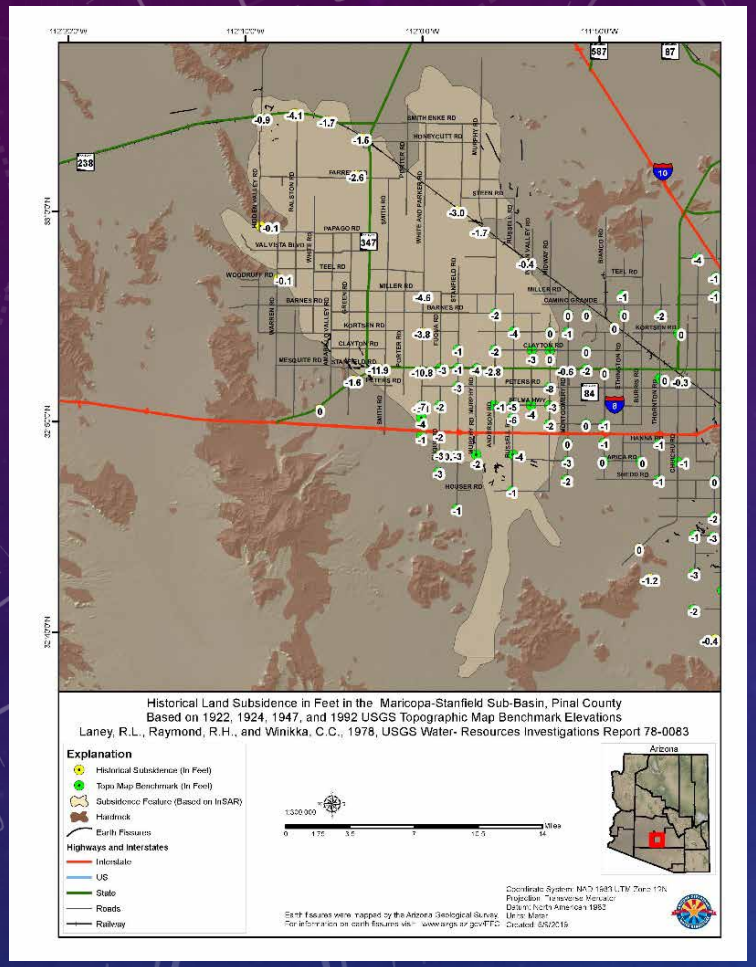


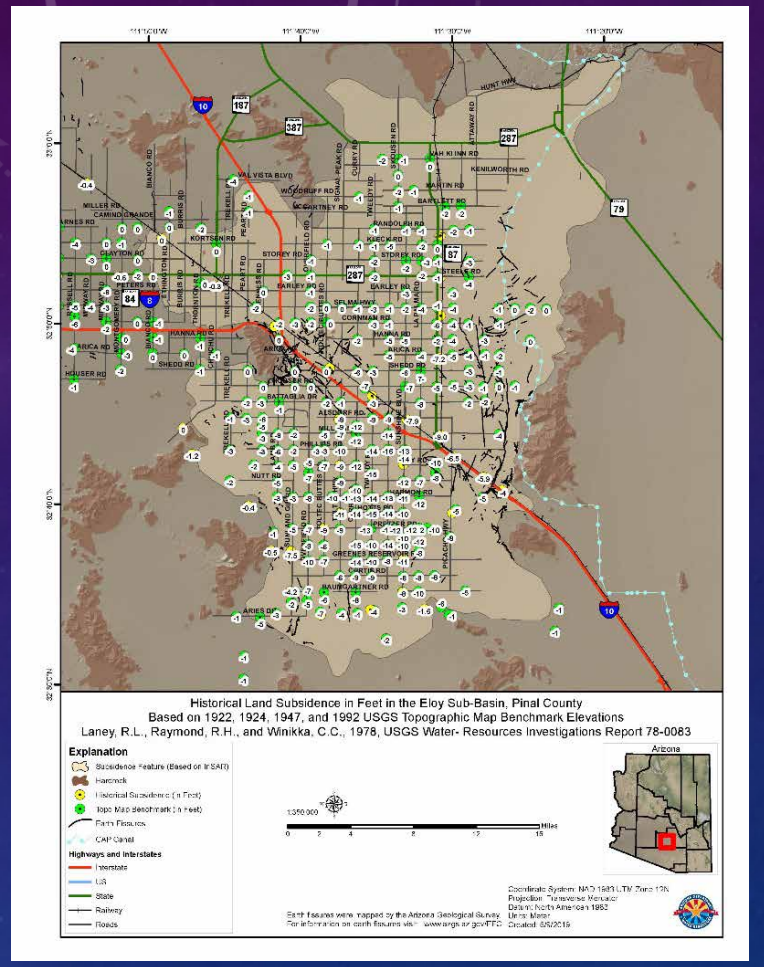




Phoenix Active Management Area Land Subsidence
U.S. Geological Survey & National Geodetic Survey Reports & Datasets

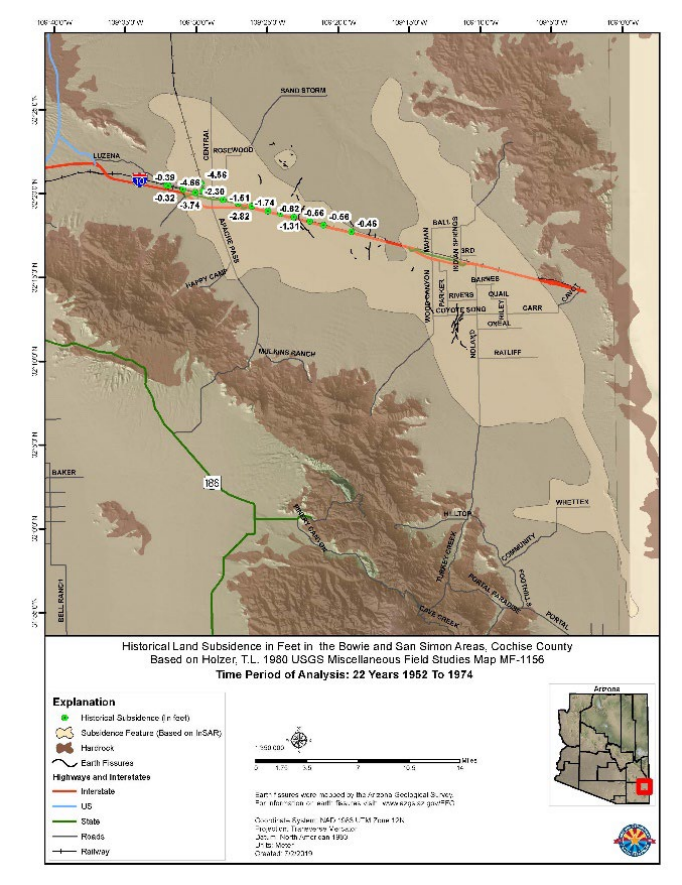
Documenting Historical Land Subsidence

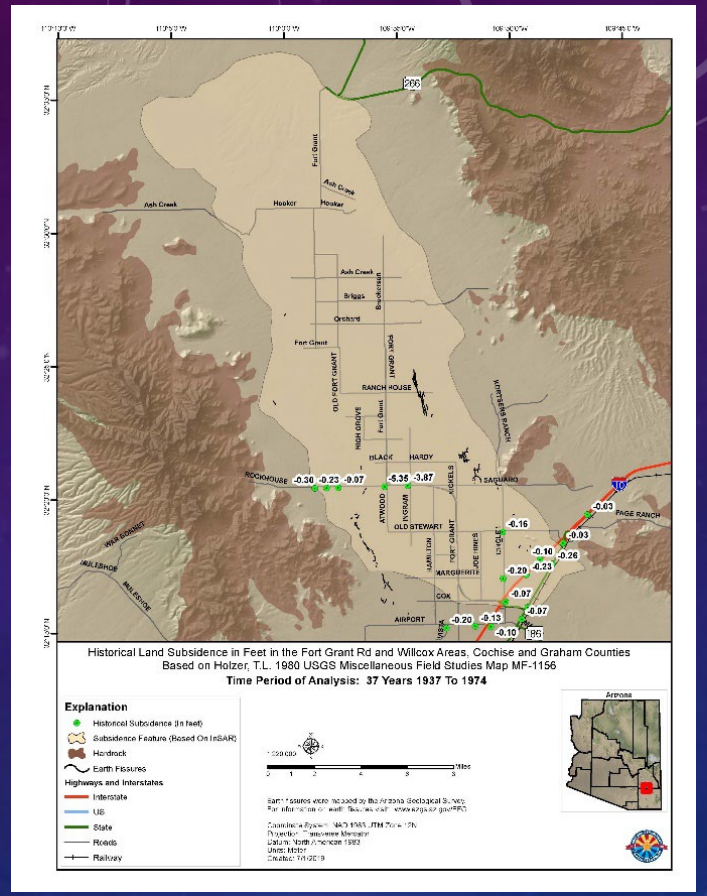


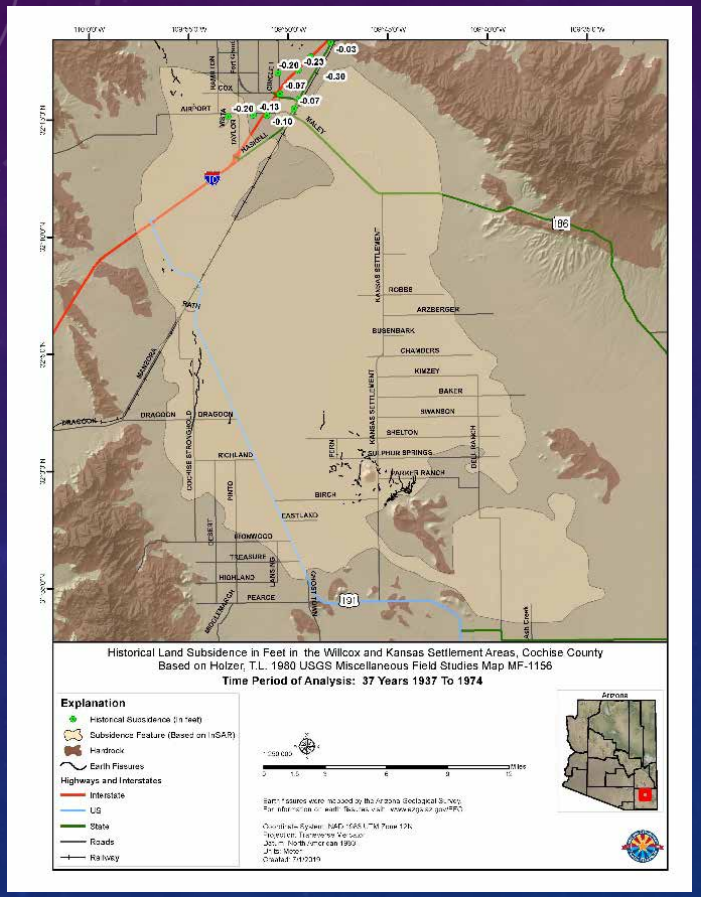


Pinal Active Management Area Land Subsidence
U.S. Geological Survey & Topo Quad Reports & Datasets

Documenting Historical Land Subsidence

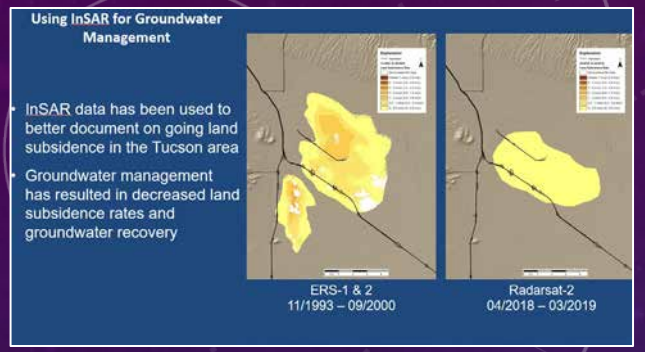




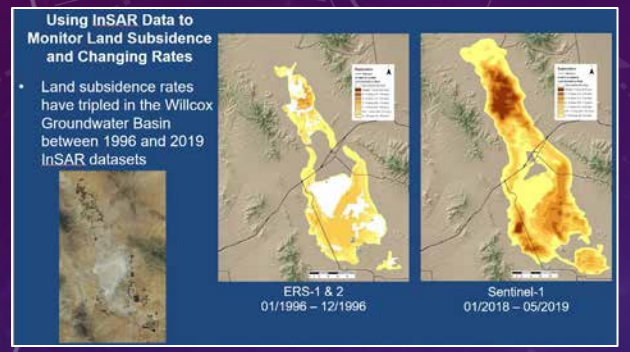


Willcox Groundwater Basin and San Simon Valley Groundwater Sub-basin USGS Reports

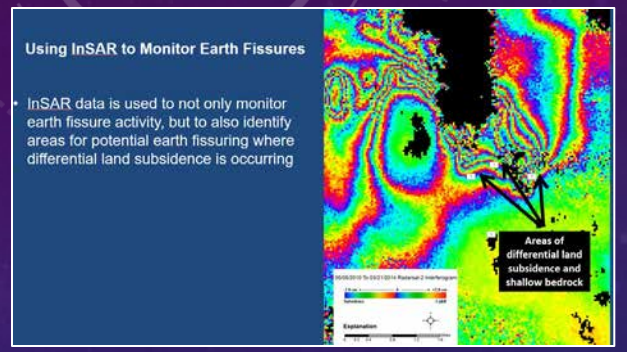
Applications of InSAR in Arizona



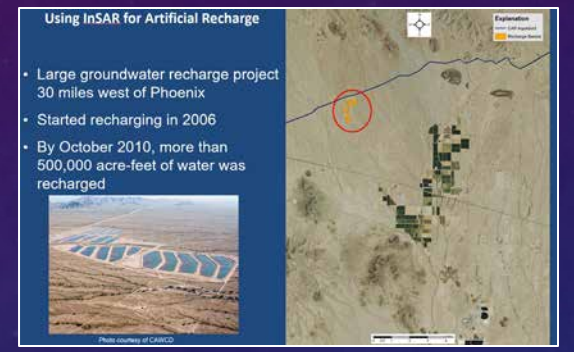
Groundwater Management



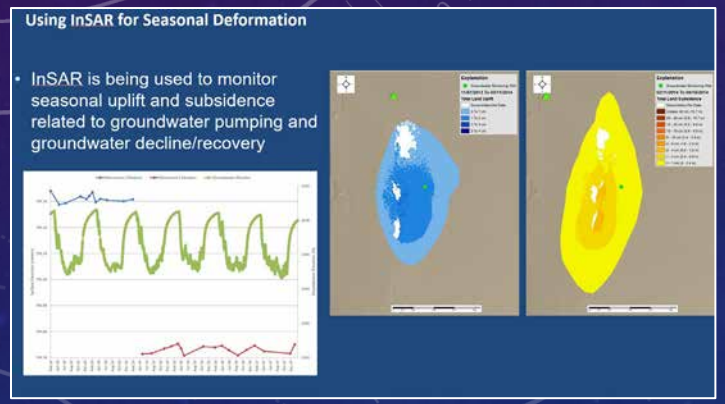
Land Subsidence



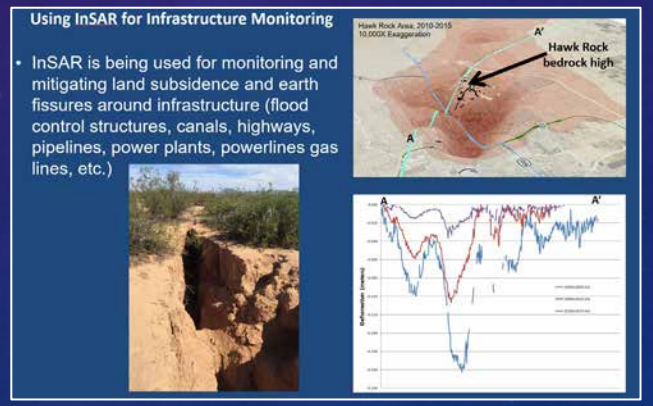
Earth Fissures



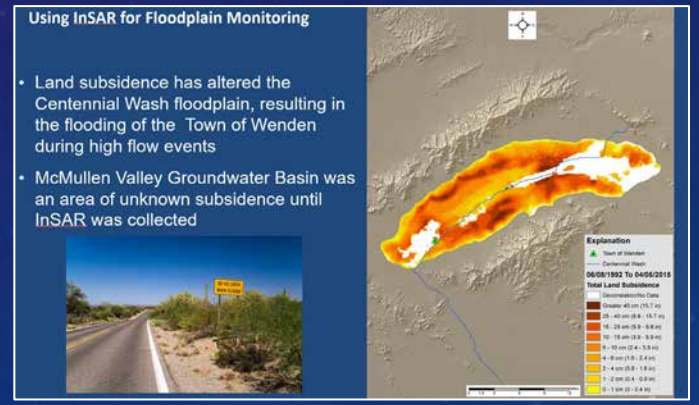
Recharge



Seasonal Deformation



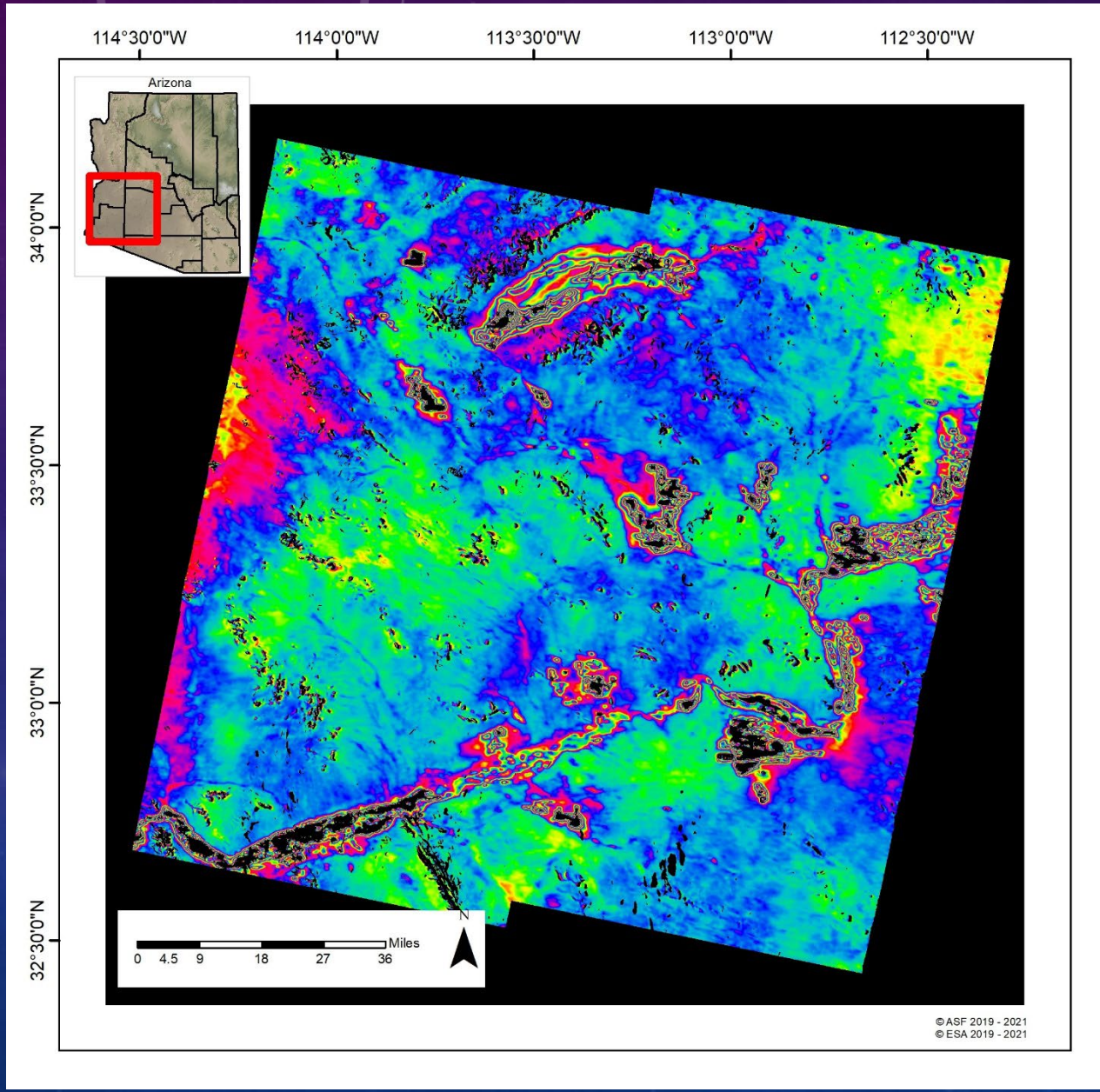
Infrastructure



Floodplains

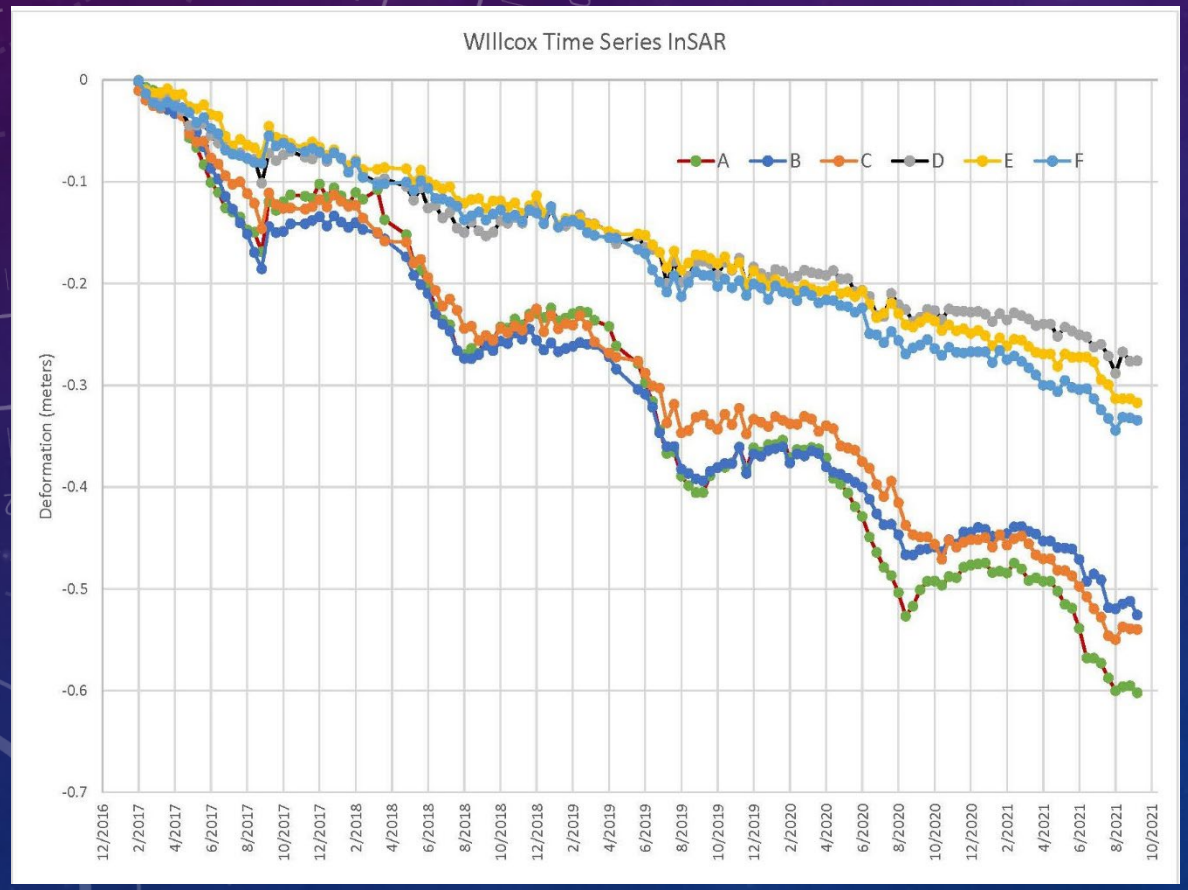
Sentinel-1 Data

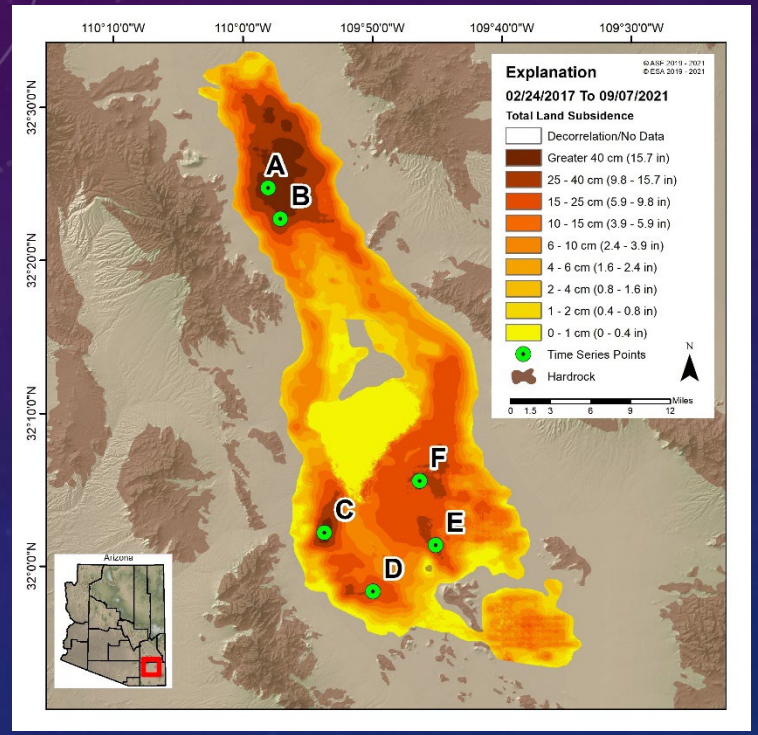
- Open data policy (FREE!!)
- Short temporal baselines (12-day repeat)
- Larger swath
- 02/2017 - 01/2021 interferogram
- Stack uses 112 collects



Sentinel-1 Data

- Able to leverage large data stacks (133 collects of Sentinel-1) to evaluate seasonal deformation and annual land subsidence





Sentinel-1
02/2017 – 09/2021
Fort Grant Rd and
Kansas Settlement
Subsidence Features

Documenting and Preserving GNSS Data

Shared Solution

PID: DV1479
Designation: X 479
Stamping: X 479 1981
Stability: Most reliable; expected to hold position well
Setting: Mat foundation or concrete slab other than pavement
Mark Condition: G
Description: X 479 is located in the McMullen Valley land subsidence feature being monitored by the Arizona Department of Water Resources using Interferometric Synthetic Aperture Radar (InSAR) data. In addition to the InSAR data, ADWR collects static GNSS data on several monuments in the area annually. This elevation should be verified before using as a vertical control point. For more information on the McMullen Valley land subsidence feature or land subsidence in Arizona, visit www.azwater.gov
Observed: 2022-04-26T14:01:00Z more obs 2020-11-09
Source: OPUS - page5 2008.25

Close-up View

REF_FRAME: NAD_83(2011) | EPOCH: 2010.0000 | SOURCE: NAVD88 (Computed using GEOID18) | UNITS: m | SET PROFILE | DETAILS

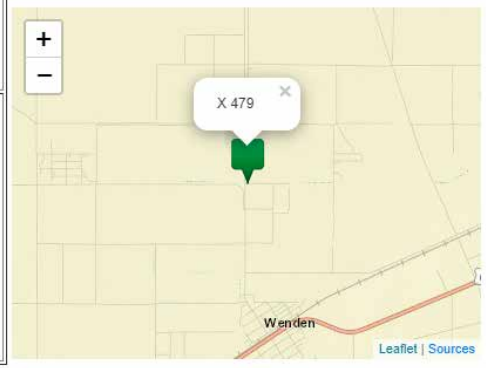
LAT:	33° 50' 29.04871" ± 0.008 m	
LON:	-113° 32' 40.76372" ± 0.005 m	
ELL HT:	552.525 ± 0.014 m	
X:	-2118569.464 ± 0.011 m	
Y:	-4862009.779 ± 0.011 m	
Z:	3532156.407 ± 0.007 m	
ORTHO HT:	583.065 ± 0.056 m	

	UTM 12	SPC 203(AZ W)
NORTHING:	3747484.198m	315093.283m
EASTING:	264541.028m	232364.539m
CONVERGENCE:	-1.41776111°	0.11435556°
POINT SCALE:	1.00028351	0.99993778
COMBINED FACTOR:	1.00019675	0.99985105

CONTRIBUTED BY

bnmihlfeith
Arizona Department of Water Resources

Horizon View



The NGS Data Sheet

See file dsdata.pdf for more information about the datasheet.

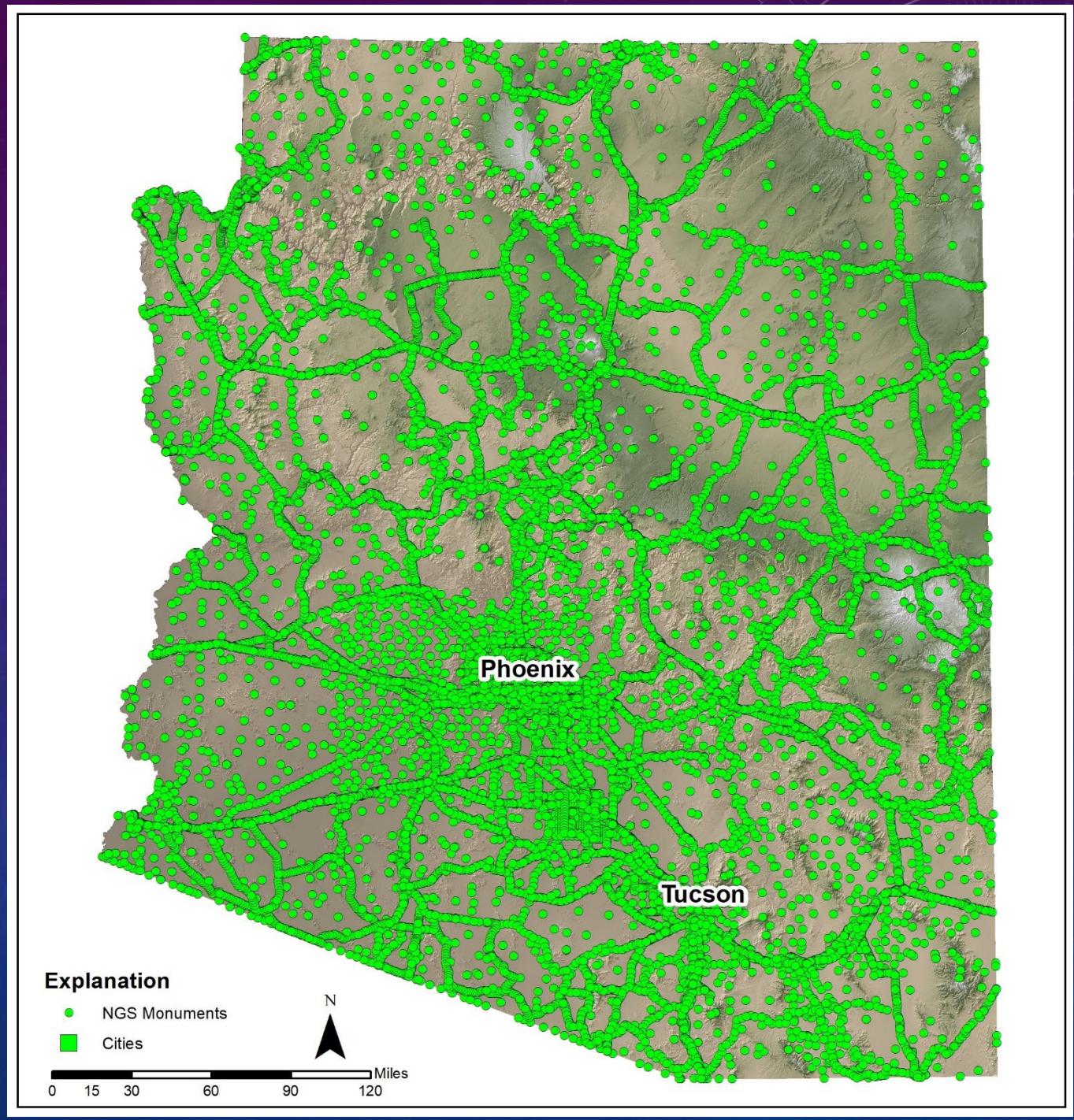
```
PROGRAM = datasheet95, VERSION = 8.12.5.4
1        National Geodetic Survey,   Retrieval Date = SEPTEMBER 23, 2019
 DV1479 ***********************************************************************
 DV1479  DESIGNATION -  X 479
 DV1479  PID         -  DV1479
 DV1479  STATE/COUNTY-  AZ/LA PAZ
 DV1479  COUNTRY     -  US
 DV1479  USGS QUAD   -  SALOME (1990)
 DV1479
 DV1479                         *CURRENT SURVEY CONTROL
 DV1479 ______________________________________________________________________
 DV1479* NAD 83(1986) POSITION- 33 50 29.04   (N) 113 32 40.76   (W)   HD_HELD1
 DV1479* NAVD 88 ORTHO HEIGHT -   584.679 (meters)     1918.23  (feet) ADJUSTED
 DV1479 ______________________________________________________________________
 DV1479  GEOID HEIGHT    -        -30.540 (meters)                     GEOID18
 DV1479  DYNAMIC HEIGHT  -        583.987 (meters)     1915.96  (feet) COMP
 DV1479  MODELED GRAVITY -    979,434.7   (mgal)                       NAVD 88
 DV1479
 DV1479  VERT ORDER      -  FIRST     CLASS II
 DV1479
 DV1479.The horizontal coordinates were determined by differentially corrected
 DV1479.hand held GPS observations or other comparable positioning techniques
 DV1479.and have an estimated accuracy of +/- 3 meters.
 DV1479.
 DV1479.The orthometric height was determined by differential leveling and
 DV1479.adjusted by the NATIONAL GEODETIC SURVEY
 DV1479.in June 1991.
 DV1479
 DV1479.Significant digits in the geoid height do not necessarily reflect accuracy
 DV1479.GEOID18 height accuracy estimate available here.
 DV1479
 DV1479.Click here to see if photographs exist for this station.
 DV1479
 DV1479.The dynamic height is computed by dividing the NAVD 88
 DV1479.geopotential number by the normal gravity value computed on the
 DV1479.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
 DV1479.degrees latitude (g = 980.6199 gals.).
 DV1479
 DV1479.The modeled gravity was interpolated from observed gravity values.
 DV1479
```

584.679 meters in 1991 and 583.065 meters in 2022

-1.614 meters (-5.30 feet) of land subsidence since 1991

Surveying

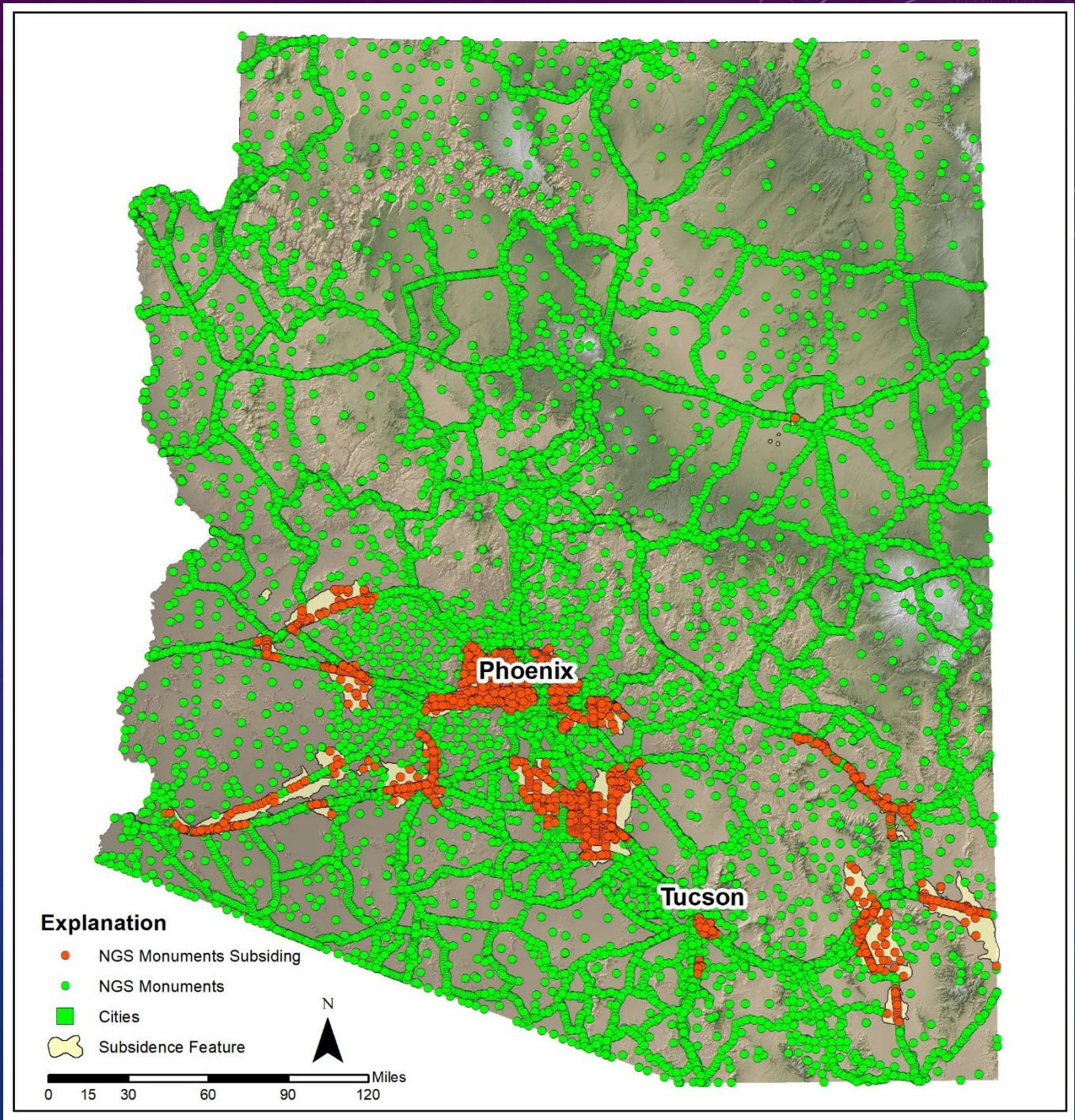
- Is Surveying Control Stable?



Surveying

- Land subsidence is compromising vertical surveying control monuments
- Surveying control should be verified

2,669 Monuments Affected by Land Subsidence



Surveyed Elevations May Not Be Accurate

NISAR Mission

- A dedicated U.S. and Indian InSAR mission, optimized for studying hazards and global environmental change
- Launch Date – January 2024
- Open data (FREE!)
- 12-day repeat
- L-Band and S-Band
- Data and products available through Alaska Satellite Facility

Using InSAR for Decision Making in Arizona

- A major step with the InSAR program is providing the data to those who need it for their own monitoring, mitigation, planning, and design projects
- Land subsidence maps are updated every spring which reflect the past 12 months of InSAR data collection
- InSAR data (wrapped and unwrapped interferograms) can be requested by anyone (consultant, public, other agency, etc.)
- The land subsidence maps/InSAR data, earth fissure data, groundwater level data, groundwater pumping data, and well-log data are a data synergy and are all critical datasets that are needed to properly monitor, investigate, and mitigate land subsidence and are all accessible through ADWR's website

What does the Future Hold?

- Continue collecting InSAR data and making data available to public
- Continue to push for elevation data from NGS for level lines in Arizona
- Continue to collaborate with the scientific community in Arizona in regard to subsidence monitoring, support/expand the CORS network however we can, and participate with geodetic surveying campaigns when available

Thank you

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