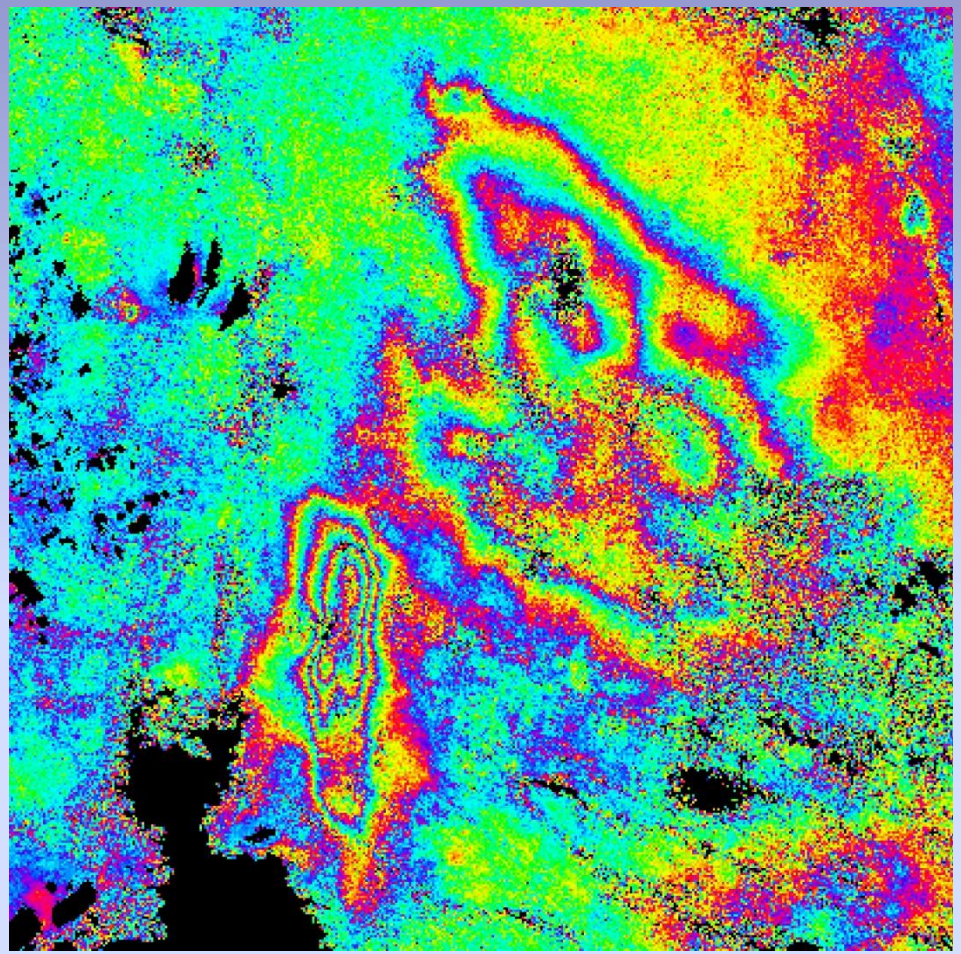
Arizona Department of Water Resources Land Subsidence Monitoring Program
Interferometric Synthetic Aperture Radar (InSAR)

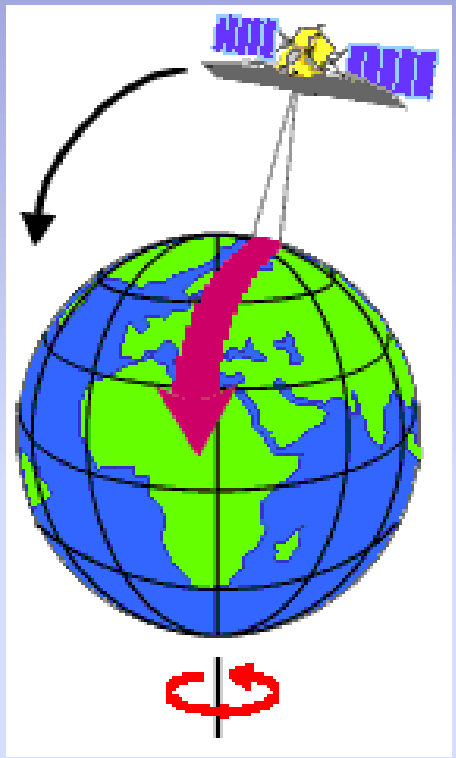


Brian D. Conway
Hydrologist/Supervisor
Geophysics-Surveying Unit

Tucson AMA GUAC Meeting, August 19, 2015

Synthetic Aperture Radar (SAR)

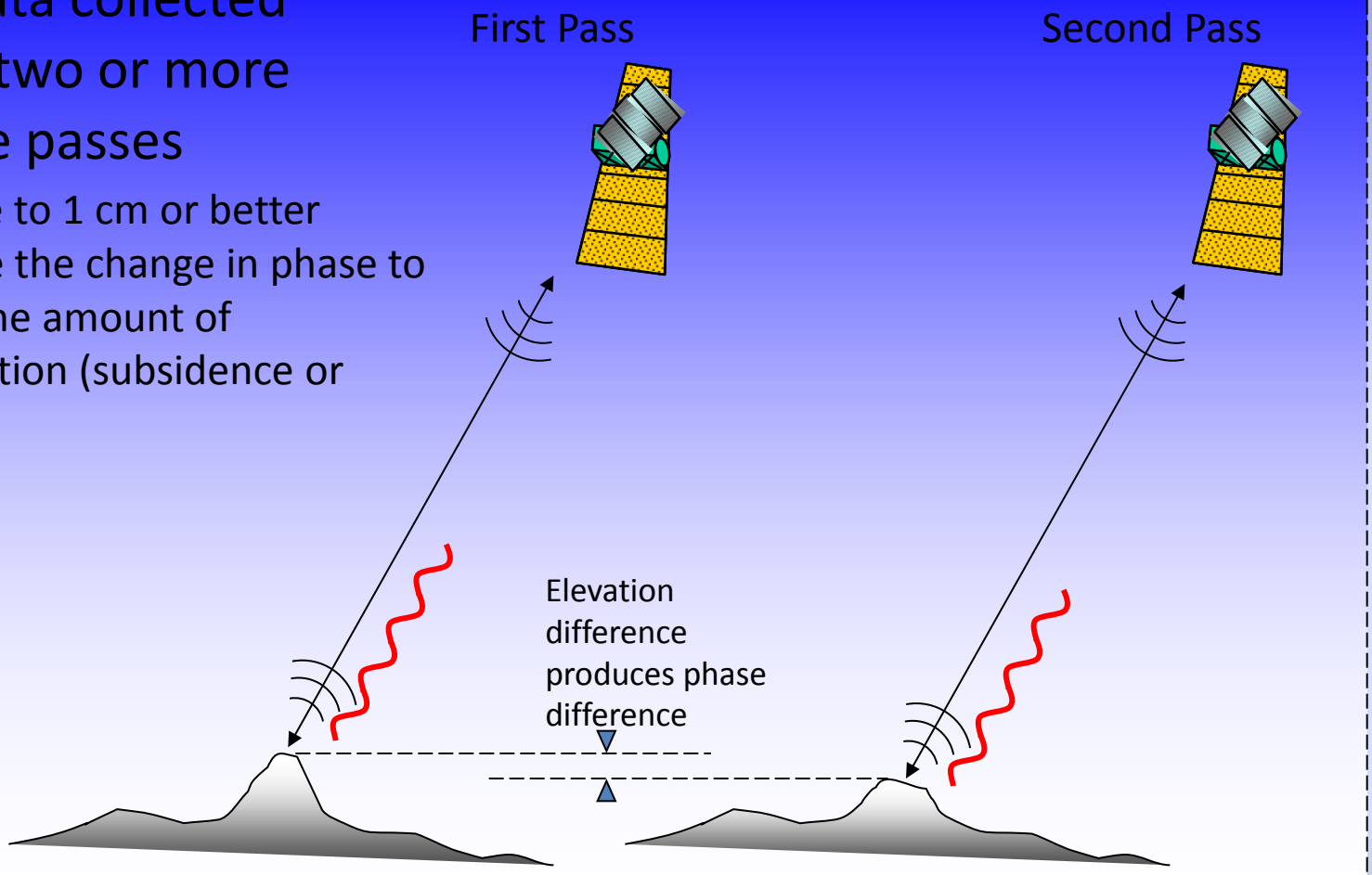
- Active sensor (day/night/clouds)
- Near Circular, Polar Orbit
- Repeat cycle 8-46 days
- Satellites need to be tasked

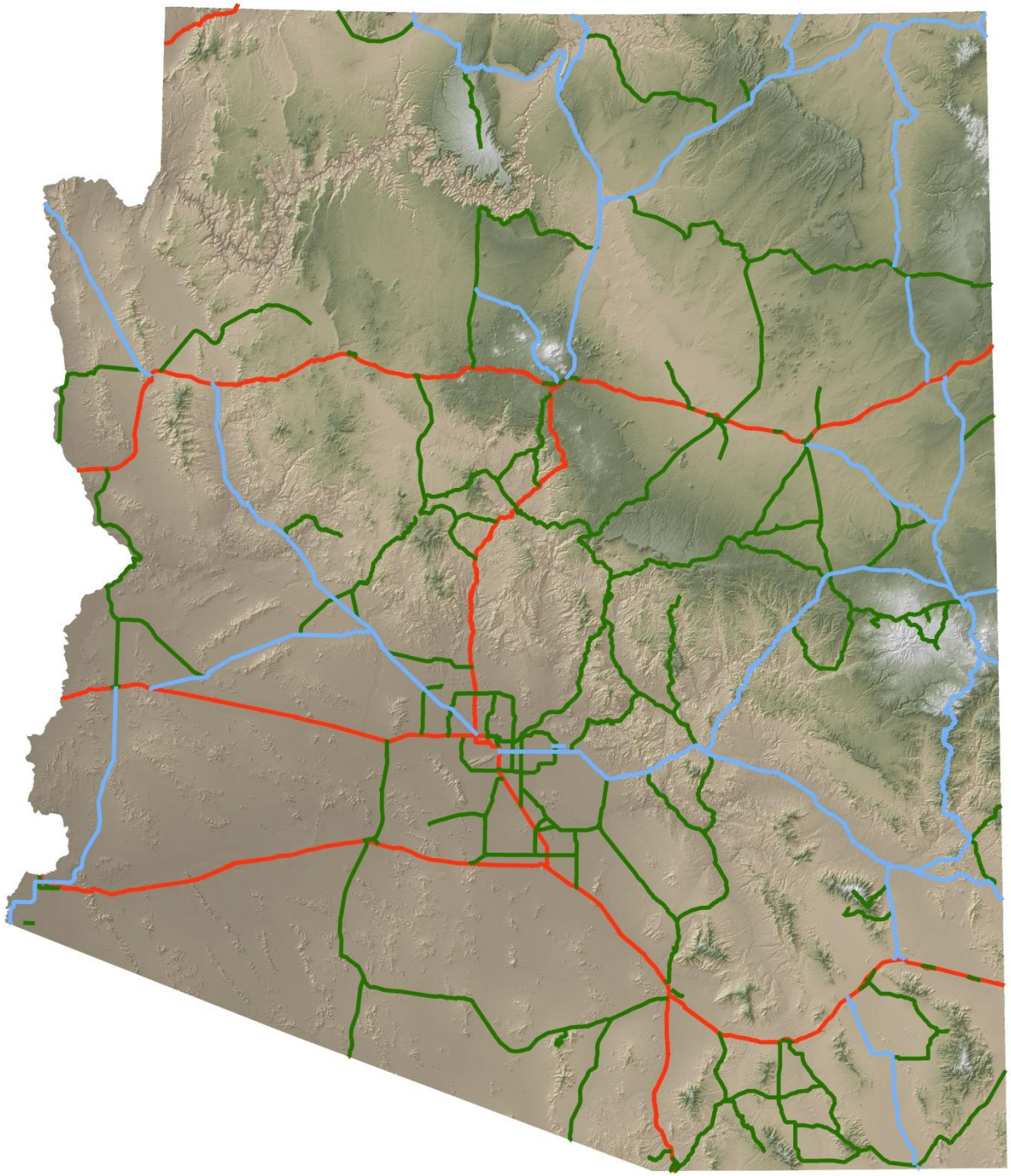


Differential Synthetic Aperture Radar (DiffSAR)
Process SAR Data Using Interferometry

Uses data collected during two or more satellite passes

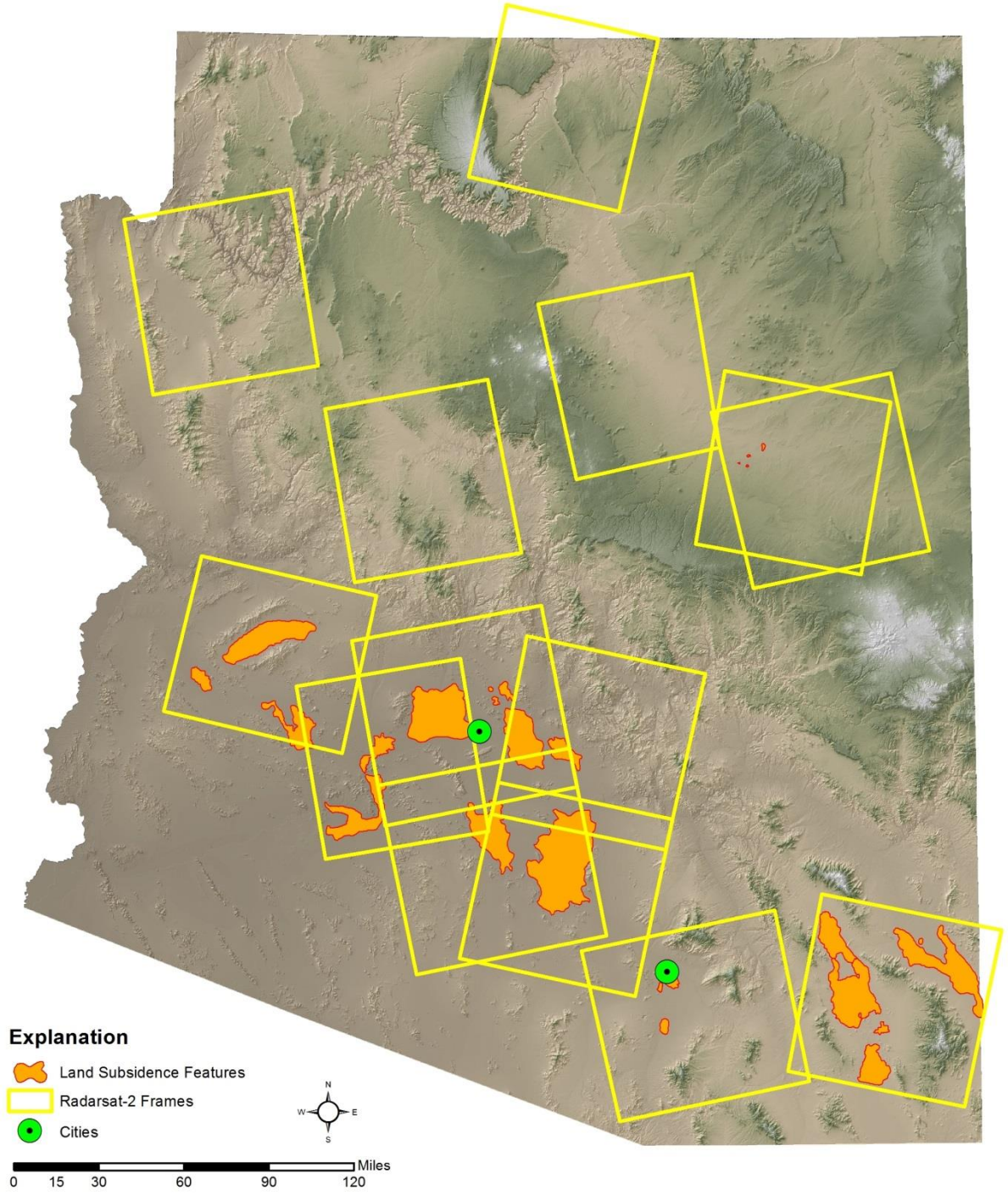
- Accurate to 1 cm or better
- Measure the change in phase to determine amount of deformation (subsidence or uplift)





ADWR InSAR Program

- Fully Operational in 2005 (Completion of 3-Year NASA Grant)
- Started collecting data over the Phoenix and Tucson AMA's
- Program has been expanded to cover the entire state through external cooperative funding



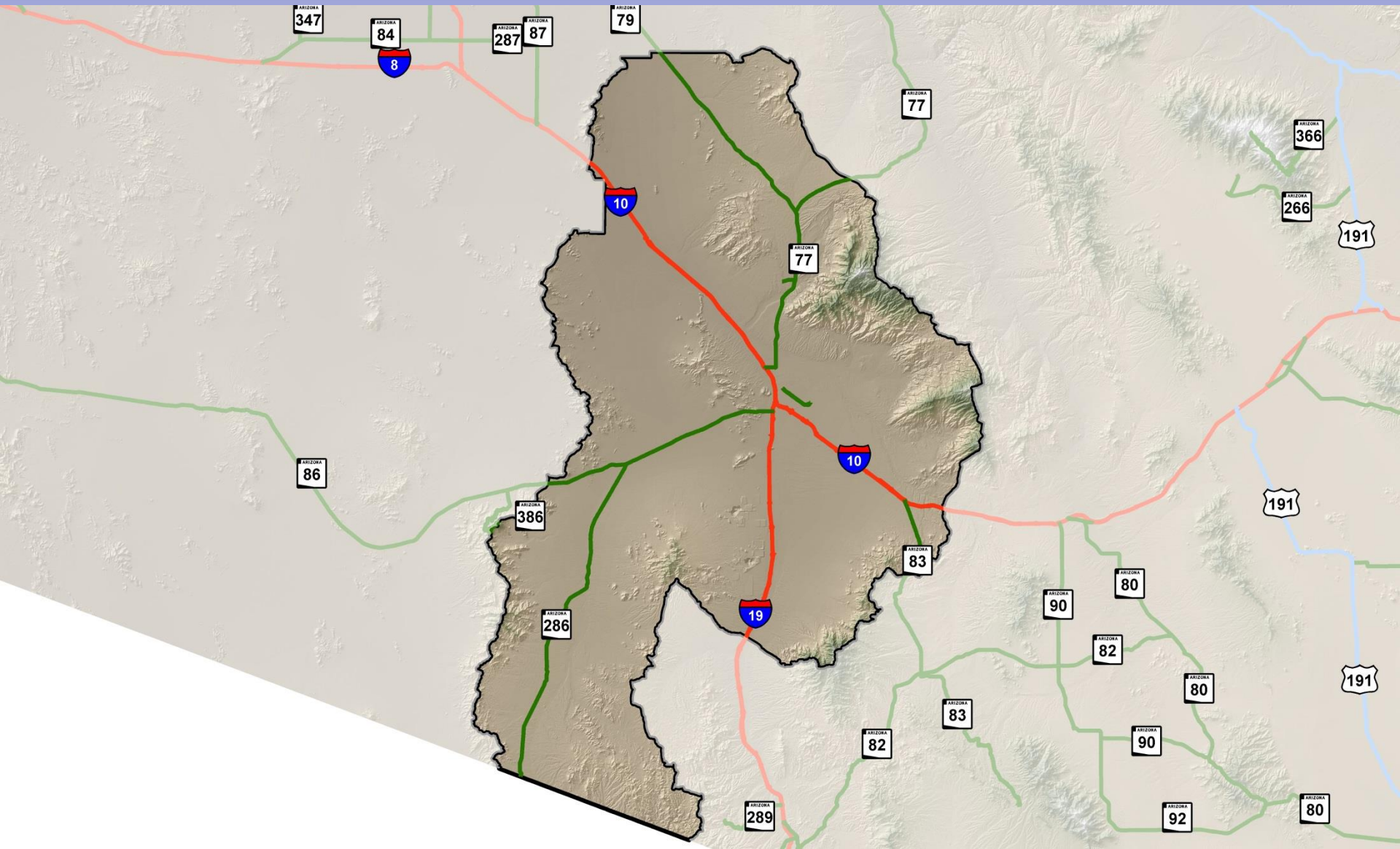
ADWR InSAR Program

- Identified more than 2,800 mi² of land subsidence areas
- Collect InSAR data over more than 50,000 square miles
- Provide land subsidence maps covering various periods of time on ADWR's website
- Cooperate with 14 Federal, State, County, and Local Agencies

ADWR InSAR Program Cooperators

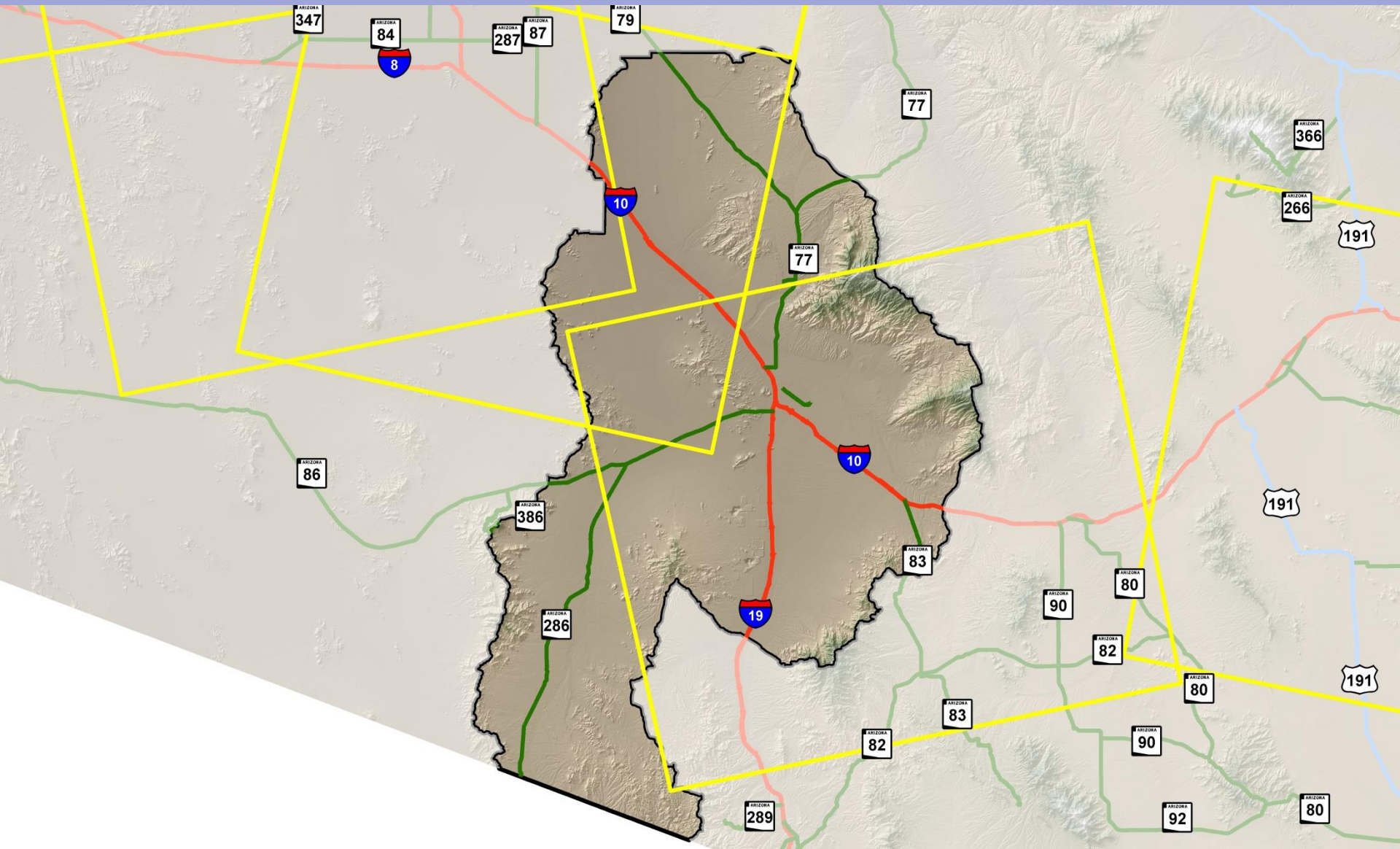
- Flood Control District of Maricopa County
- Pinal County Flood Control District
- Arizona Department of Transportation
- Arizona State Land Department
- Central Arizona Project
- Metropolitan Domestic Water Improvement District
- Salt River Project
- Community Water Company
- City of Scottsdale
- Cochise County
- Arizona Geological Survey
- Petrified Forest National Park
- City of Phoenix
- City of Mesa

Land Subsidence Monitoring in the Tucson AMA

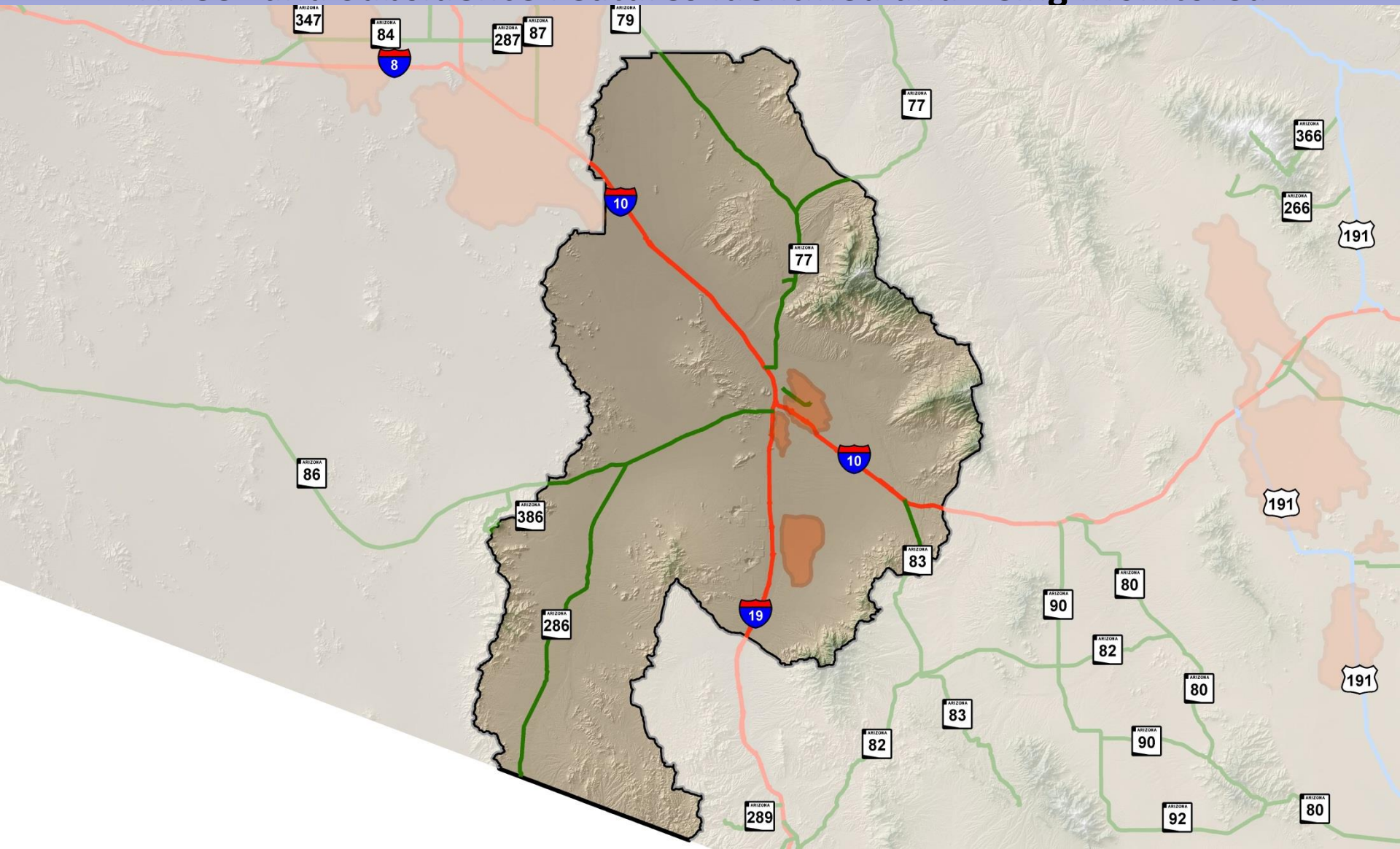


Land Subsidence Monitoring in the Tucson AMA

InSAR Frames That Cover the Tucson AMA



Land Subsidence Monitoring in the Tucson AMA
Land Subsidence Features in the Tucson AMA
Identified with ADWR InSAR Data
Three Land Subsidence Features Identified and Being Monitored



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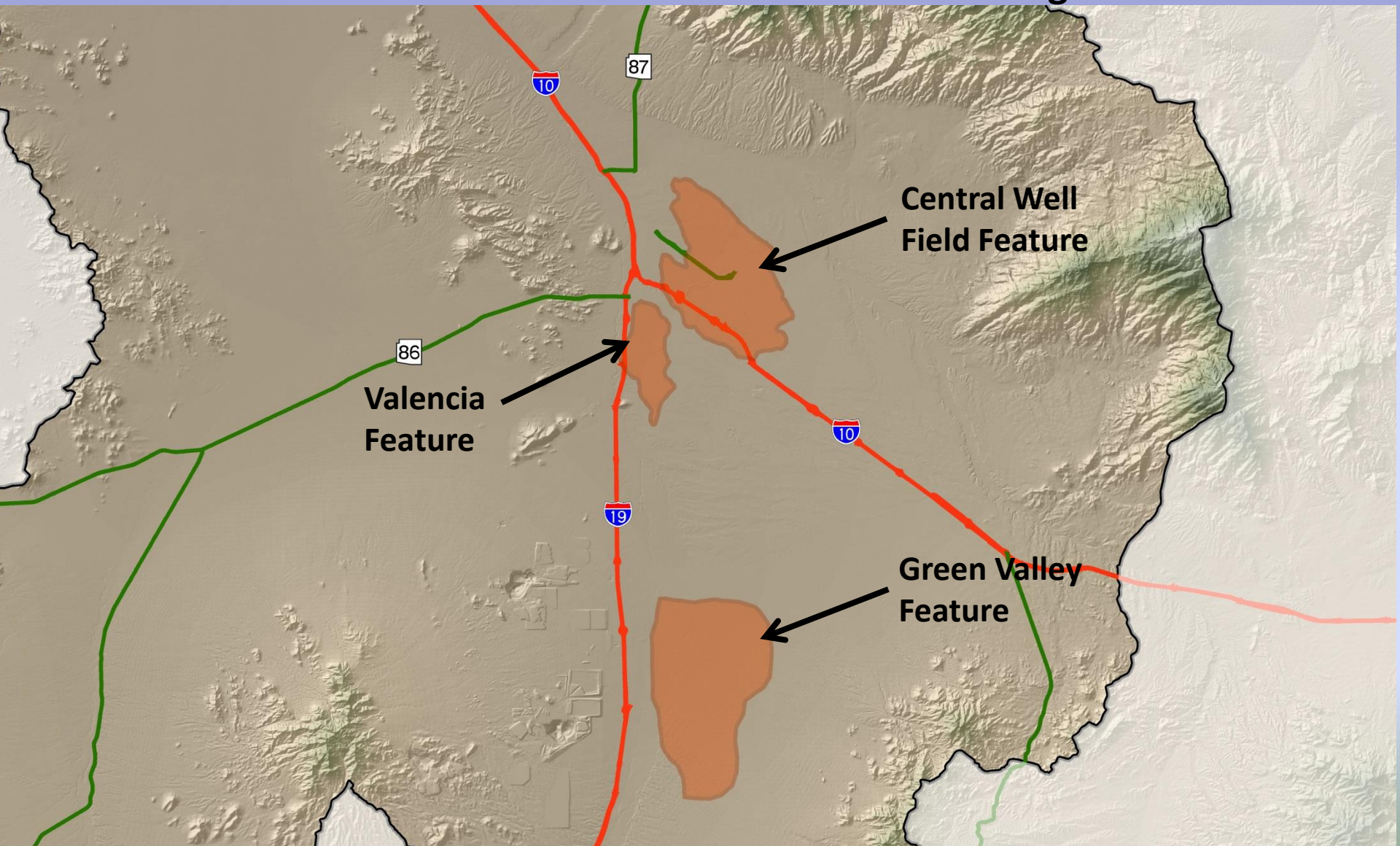

ADWR's Land Subsidence Website

Land Subsidence in Arizona

In the News...

Recently the Department has begun working with NASA's Jet Propulsion Laboratory to collect data through NASA's Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) program in Cochise County to improve data collection and to complement the Department's satellite-based Inteferometric Synthetic Aperature Radar (InSAR) data. The Arizona Department of Water Resources has been collecting and processing InSAR data since 2002 to monitor land subsidence throughout Arizona. The Department has identified more than 25 land subsidence features that cover more than 1,100 square miles.

NASA's Uninhabited Aerial Vehicle Synthetic Aperture Radar News Release

Radar Plane Scans South American Landscapes (Yahoo! News)

NEW! **Interactive Arizona Land Subsidence Map**

Arizona Land Subsidence Areas

Scottsdale/NE Phoenix	McMullen Valley	Picacho/Eloy	Fort Grant Rd
West Valley	Harquahala Valley	Maricopa-Stanfield	Kansas Settlement
Hawk Rock	Ranegras Valley	Tucson	Elfrida
Buckeye	Gila Bend	Green Valley	Bowie/San Simon
Holbrook Sinks			

What is Land Subsidence

ADWR's Land Subsidence Website

Land Subsidence in Arizona

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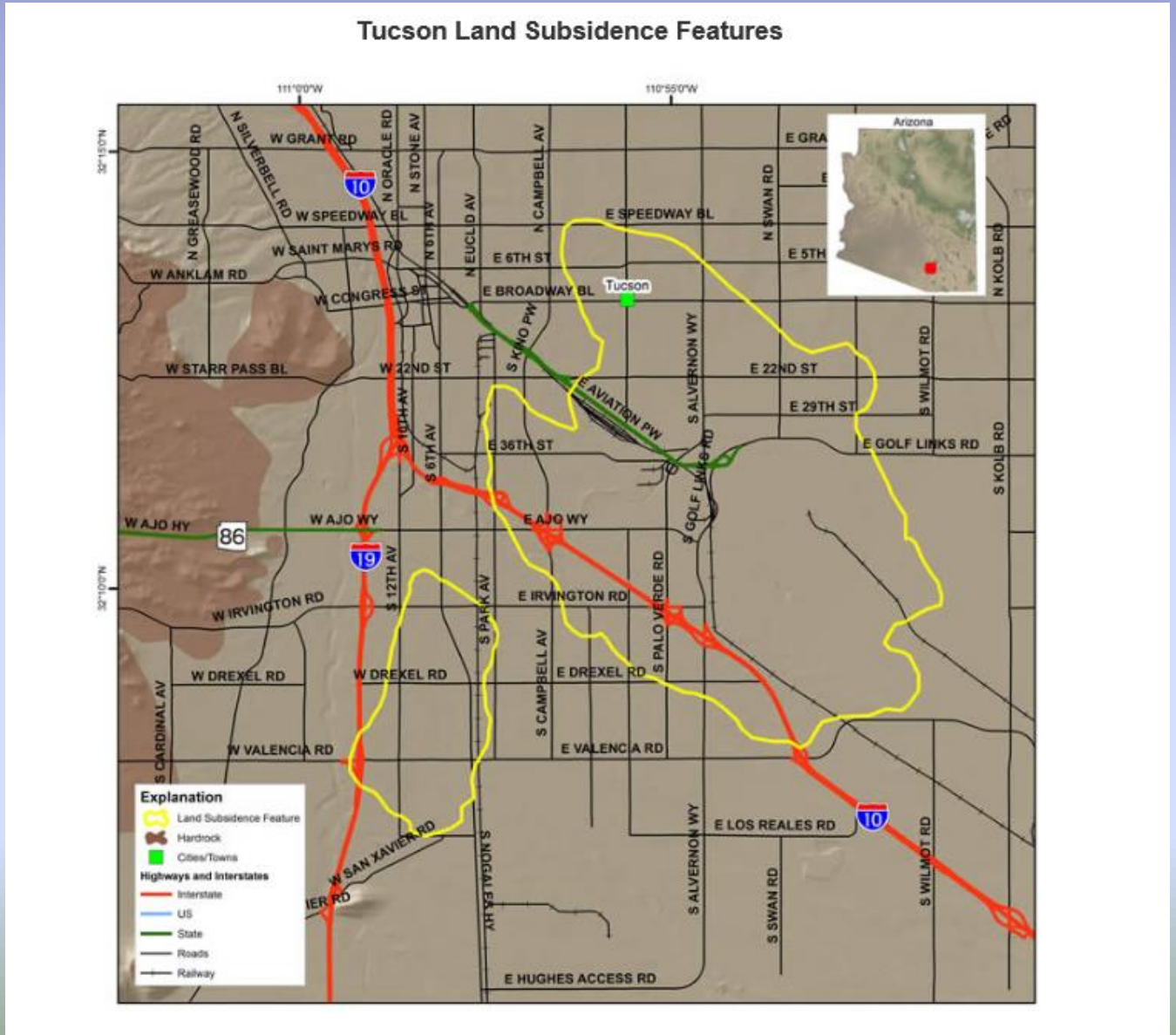
ADWR's Land Subsidence Website
Example of a Land Subsidence Feature Webpage
Tucson Land Subsidence Feature



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Tucson Land Subsidence Feature
List of Available Land Subsidence Maps

Land Subsidence Rate Maps:

The land subsidence rate maps show the rate of land subsidence per year (cm/yr). These maps are used to illustrate any changes in land subsidence rates over time. All the land subsidence rate maps utlize the same color scale.

NOV-1993 to SEP-2000	FEB-2009 to JAN-2010	MAY-2012 to MAY-2014

Land Subsidence Maps:

The land subsidence maps show the total land subsidence (cm) over a specific period of time (1-year, 2-year, 4-year, etc). All the land subsidence maps utlize the same color scale.

NOV-1993 to SEP-2000	FEB-2007 to MAR-2008	FEB-2008 to JAN-2010
FEB-2003 to JAN-2010	FEB-2007 to FEB-2009	FEB-2009 to JAN-2010
APR-2006 to APR-2008	FEB-2008 to FEB-2009	MAR-2008 to MAR-2011
MAY-2010 to APR-2012	APR-2011 to MAY-2012	APR-2011 to MAY-2013
MAY-2010 to APR-2013	MAY-2010 to MAY-2014	MAY-2012 to MAY-2014
APR-2013 to APR-2015	MAY-2010 to APR-2015	

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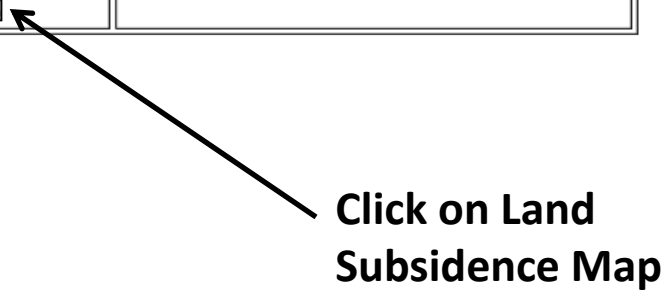
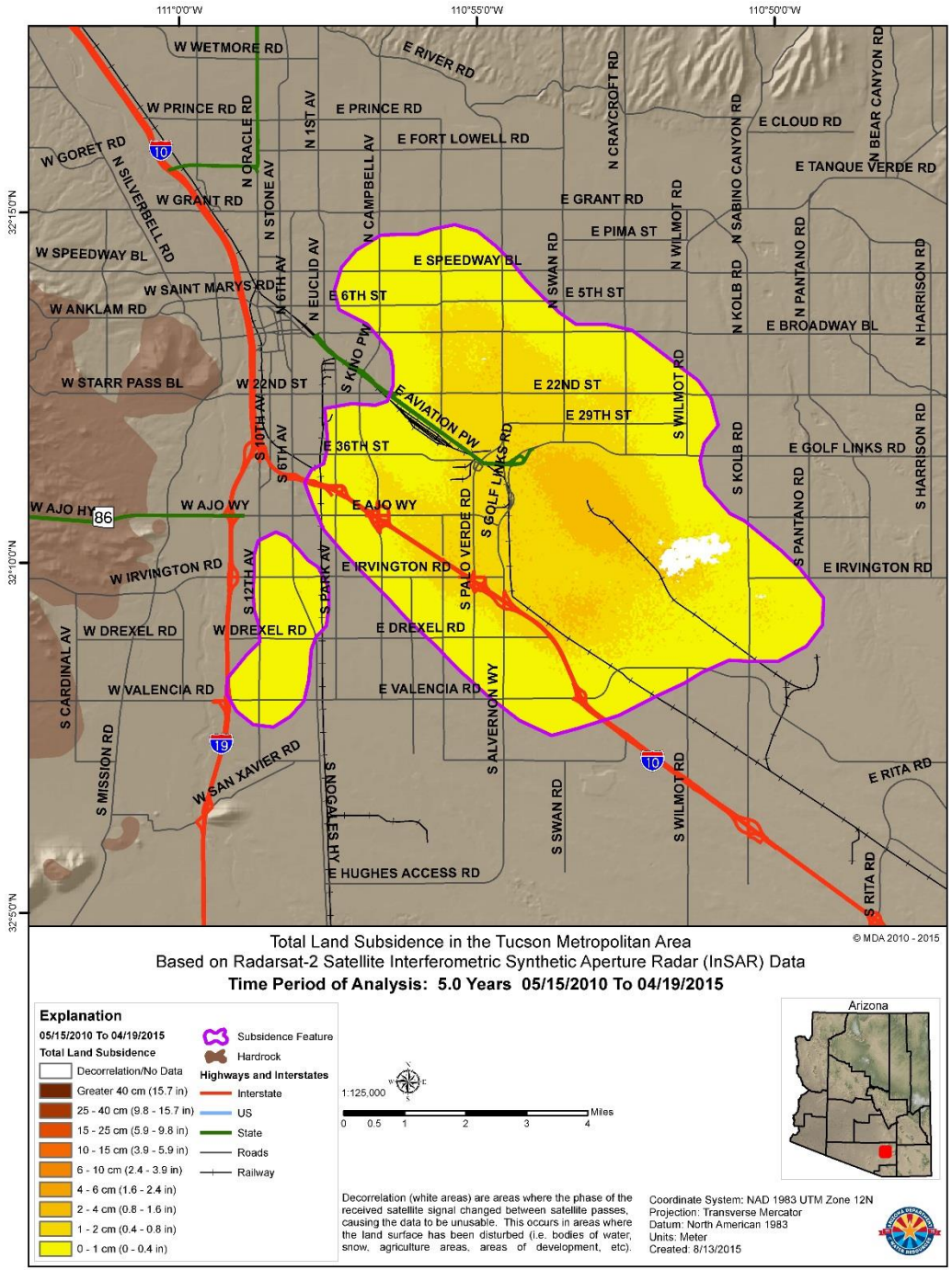
APR-2006 to APR-2008	FEB-2008 to FEB-2009	MAR-2008 to MAR-2011
MAY-2010 to APR-2012	APR-2011 to MAY-2012	APR-2011 to MAY-2013
MAY-2010 to APR-2013	MAY-2010 to MAY-2014	MAY-2012 to MAY-2014
APR-2013 to APR-2015	MAY-2010 to APR-2015	



ADWR InSAR Program



Total Land Subsidence in the Tucson Metropolitan Area
Based on Radarsat-2 Satellite Interferometric Synthetic Aperture Radar (InSAR) Data
Time Period of Analysis: 5.0 Years 05/15/2010 To 04/19/2015

© MDA 2010 - 2015

Explanation

05/15/2010 To 04/19/2015
Total Land Subsidence
- Decorrelation/No Data
- Greater 40 cm (15.7 in)
- 25 - 40 cm (9.8 - 15.7 in)
- 15 - 25 cm (5.9 - 9.8 in)
- 10 - 15 cm (3.9 - 5.9 in)
- 6 - 10 cm (2.4 - 3.9 in)
- 4 - 6 cm (1.6 - 2.4 in)
- 2 - 4 cm (0.8 - 1.6 in)
- 1 - 2 cm (0.4 - 0.8 in)
- 0 - 1 cm (0 - 0.4 in)

Subsidence Feature
Hardrock

Highways and Interstates
- Interstate
- US
- State
- Roads
- Railway

1:125,000
0 0.5 1 2 3 4 Miles

Arizona

Decorrelation (white areas) are areas where the phase of the received satellite signal changed between satellite passes, causing the data to be unusable. This occurs in areas where the land surface has been disturbed (i.e. bodies of water, snow, agriculture areas, areas of development, etc).

Coordinate System: NAD 1983 UTM Zone 12N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
Created: 8/13/2015

An example of a land subsidence PDF map: Tucson 2010-2015

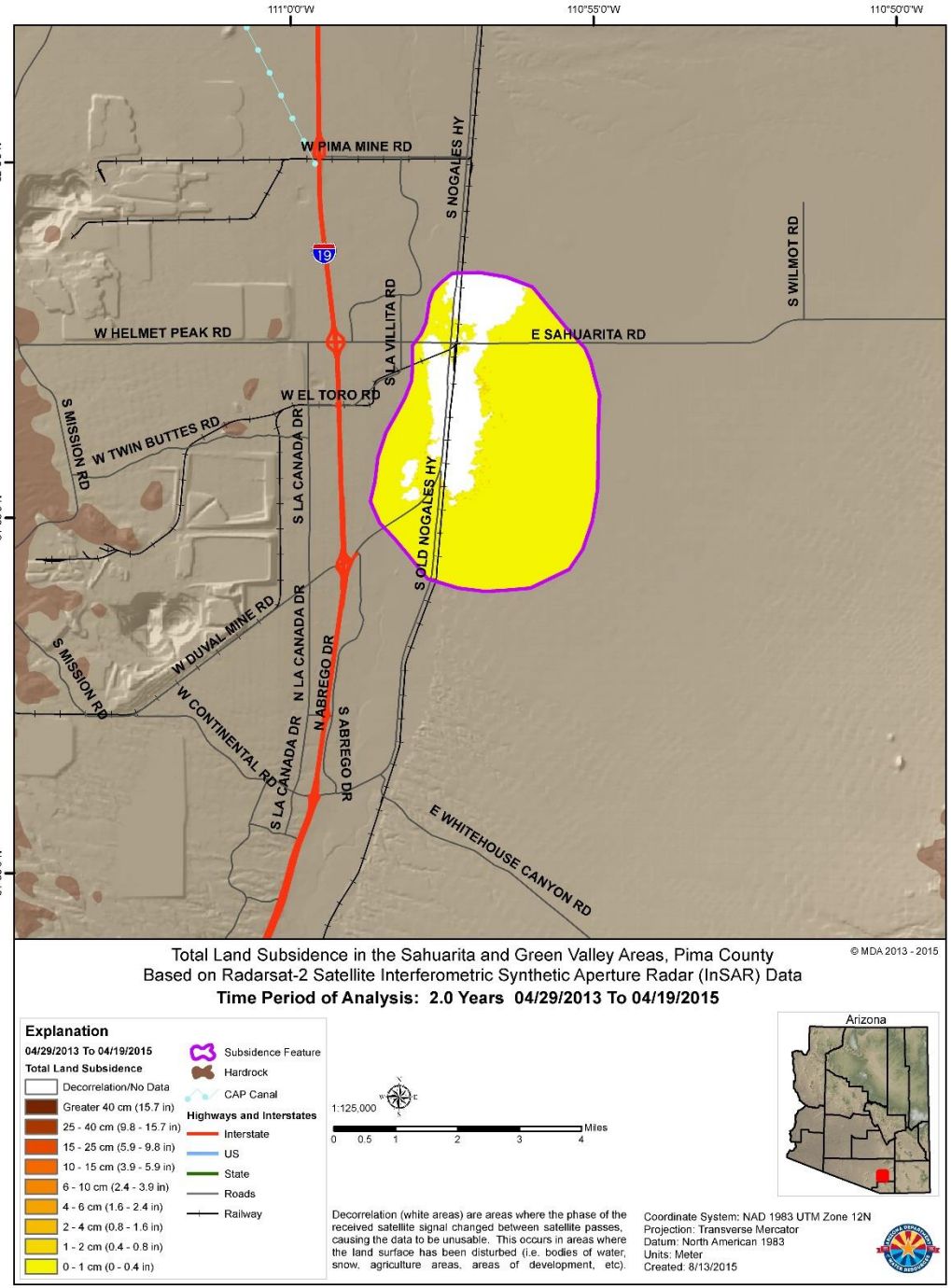
Land subsidence as high as 3.5 cm in 5-years

Land subsidence has been decreasing when comparing InSAR data back to 1992

Land subsidence maps are updated annually (late spring/early summer)

As of May 2015, more than 240 land subsidence maps are available online

ADWR InSAR Program



Green Valley 2013-2015 map

Land subsidence as high as 1.3 cm in 2-years

Green Valley feature has both a seasonal subsidence and uplift component

The Future of ADWR's InSAR Program

- ADWR has the largest State operated InSAR program in the U.S. and will continue to collect InSAR data through out State.

- ADWR will continue to work with it's InSAR cooperators and stakeholders, providing land subsidence products for their own monitoring, modeling, mitigation, and planning needs.

- ADWR will continue to update land subsidence maps on it's website each spring using the most recent InSAR data.

- ADWR continues to look for additional InSAR cooperators in the Tucson AMA to help fund data collection for the AMA.

Questions?

Brian D. Conway

bdconway@azwater.gov

602.771.8667

NASA UAVSAR Platform on a Gulfstream III Aircraft

Image Courtesy of NASA