Fact Sheet

Land Subsidence and Aquifer Storage Monitoring

Monitoring the State's Water Resources

ADWR Geophysics & Surveying Unit

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The Arizona Department of Water Resources Geophysics/Surveying Unit's primary purpose is to gather, process, and interpret land subsidence and aquifer storage data to help the Department better manage the State's water resources. The data are gathered by using survey-grade Global Positioning System (GPS) equipment, gravity meters, and Synthetic Aperture Radar (SAR) satellites. The data consist primarily of GPS positions and elevations at discrete points, absolute and relative gravity values at discrete points for depth to bedrock and aquifer storage modeling, and broad swaths of SAR data that cover several critical areas of the State.

The two primary programs supported by the Unit are the Land Subsidence Monitoring Program (LSMP) and the Aquifer Storage Monitoring Program (ASMP). In addition, the Geophysics/Surveying Unit has performed surveys and supplied data to ADWR's WQARF Program, Basic Data Unit, Transducer Unit, the Modeling Section, Water Planning Division, and the Water Engineering and Permits Division.

In the past the Geophysics/Surveying Unit has worked collaboratively with a number of outside groups to perform projects that aid the Department in water resource management, require survey-grade GPS measurements, gravity measurements, and/or InSAR data collection and analysis and are mutually beneficial to all participants involved. These groups include:

- Maricopa County Department of Transportation
- Flood Control District of Maricopa County
- Pinal County Flood Control District
- Salt River Project
- Central Arizona Project
- City of Scottsdale
- Arizona Department of Transportation
- Arizona State University
- Arizona State Land Department
- National Geodetic Survey
- United States Geological Survey
- National Aeronautics and Space Administration
- Center for Space Research
- Sea Space Corporation
- AMEC
- Cochise County

Earth fissure located at the NW Corner of Happy Rd and 195th St in Queen Creek

- Community Water Company
- Arizona Geological Survey
- Metro Water
- City of Phoenix
- City of Phoenix
- Neva Ridge Technologies

ADWR GPS Equipment and Surveying Techniques

The Geophysics/Surveying Unit uses Trimble 4800 and R8 GNSS Series survey-grade GPS receivers. The GPS equipment includes:

- 3 Trimble 4800 Rover Receivers & TSC1 Controllers
- 1 Trimble 4800 Base Receiver
- 3 Trimble R8 GNSS Rover Receiver & TSC2 Controller
- 1 Trimble R8 GNSS Base Receiver & TSC2 Controller
- 1 Trimble Trimmark II Radio
- 1 Trimble HPB450 Radio
- 2 UHF Omnidirectional Antennas with a 5dB Gain Tip
- 4 SECO 2.000 meter Fixed Height Tripods
- 4 SECO Fixed-Height Tripods w/ Collapsible Center Staff
- 3 Trimble 1.800 meter Carbon Fiber Bipods
- 3 Trimble 2.000 meter Aluminum Bipods
- Trimble Geomatics Office (TGO) Version 1.63 Software

Static GPS Survey in Cochise County

The Geophysics/Surveying Unit performs three primary types of GPS surveys to determine the horizontal and vertical position of discreet points: Static surveys, Real Time Kinematic (RTK) surveys and Post Processed Kinematic (PPK) surveys.

WQARF RTK GPS Survey

The Static survey method requires long occupation times (1 to 8 hours), multiple receivers logging data simultaneously, repeat observations, and significant post-processing to produce final results. The Static survey method is the most accurate GPS survey technique available today. The level of accuracy achieved in the final results is based on a number of factors (e.g. equipment type, occupation time, baseline distance, satellite availability and constellation geometry, and physical receiver environment). We primarily use the Static survey method when performing our land subsidence measurements.

The Real Time Kinematic (RTK) Survey style requires very short (seconds to minutes) occupation times and no post-processing of the GPS data. However, this method requires that a base station (GPS receiver occupying a location with known coordinates) is operating and broadcasting a correction signal that can be received by the GPS rover receiver. The RTK survey style is used to measure a large number of survey points, in a relatively small geographic area, in a short period of time. There is a decrease in the accuracy of the final result when compared to the static survey style, but these measurements are not normally used for land subsidence monitoring.

The Post Processed Kinematic (PPK) Survey style requires an occupation time of at least thirty seconds. This method is similar to the RTK Survey style but it does not use the broadcasting correction signal from the base station. It uses the static survey data from the base station to post process the initial point survey data.

The Trimble manufacturer's published errors associated with the Static, Real Time Kinematic, and Post Processed Kinematic Survey Styles for the R8 GNSS and 4800 Series receivers are:

RTK Errors: +/- 1cm + 2ppm Horizontal
+/- 2cm + 2ppm Vertical

Static Errors: 5mm + 1ppm (times baseline length) Horizontal
10mm + 1ppm (times baseline length) Vertical

PPK Errors: 1cm + 1ppm (times baseline length) Horizontal
2cm + 1ppm (times baseline length) Vertical

Trimble R8 RTK Base Station

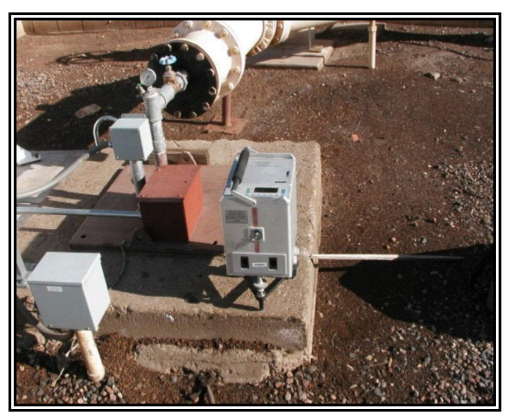
Hualapai Valley Gravity Base Station

Gravity Surveying For Depth To Bedrock Study

ADWR Gravity Meters

The Geophysics/Surveying Unit uses two Scintrex CG-3M and one Scientrex CG-5 Autograv gravimeters to perform gravity surveys. The CG-3M and CG-5 are fully automated relative microgravity meters with a reading resolution of 0.001 mgal (milligals). They are lightweight, portable and easy to use.

Relative meters measure only gravity differences between stations. Gravity values are obtained at unknown stations by first measuring a station where the absolute gravity value is known, and then measuring the unknown point. This is called a gravity 'tie.' Relative gravity meters are used because they are easier and faster to use in a fieldwork setting than absolute gravity meters.

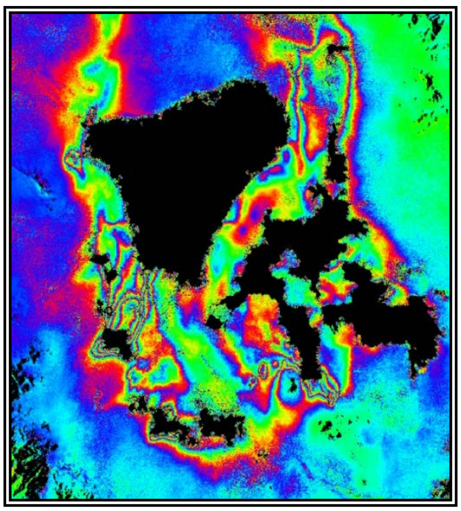


Micro gravity survey on a transducer

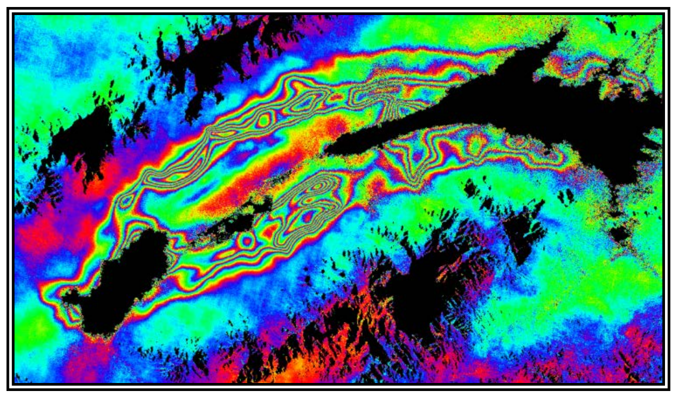
The Autograv uses a sensing element based on a fused quartz elastic system. An electrostatic restoring force and a spring are used to balance the gravitational force on the proof mass. Changes in gravity alter the position of the mass. DC voltage is applied to capacitor plates to produce an electrostatic force on the mass, restoring it to a null position. This feedback voltage is a measure of the relative value of gravity.

ADWR Synthetic Aperature Radar (SAR) Program

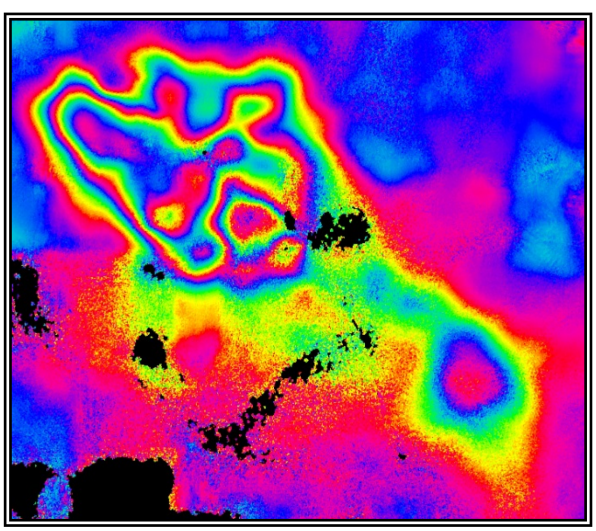
Synthetic Aperture Radar (SAR) is a side-looking, active (produces its own illumination), radar imaging system that transmits a pulsed microwave signal towards the earth and records both the amplitude and phase of the back-scattered signal that returns to the antenna. Interferometric SAR (InSAR) is a technique that compares the amplitude and phase signals received during one pass of the SAR platform over a specific geographic area with the amplitude and phase signals received during a second pass of the platform over the same area but at a different time. InSAR techniques, using satellite based SAR platform data, can be used to produce land surface deformation products with cm-scale vertical resolution, 30-m pixel resolution, and covering areas 100 km x 100 km (in standard beam modes).



Cochise County Interferogram 2010-2012



McMullen Valley 2004-2010 Interferogram



Hawk Rock 2010-2014 Interferogram

ADWR has been using InSAR since 2002 to determine the spatial extent, deformation rates, and time-series history of more than twenty land subsidence features within the Phoenix, Pinal, and Tucson Active Management Areas (AMAs), and several groundwater basins outside Active Management Areas in Maricopa, La Paz, Cochise, and Navajo Counties. With funding help from NASA, and technological help from the Vexcel Corporation, the Center for Space Research at the University of Texas at Austin, and Neva Ridge Technologies, ADWR has developed an application using SAR data and InSAR processing techniques to perform long-term monitoring of land subsidence within Arizona for the purpose of improved water resources management.