McDonald Geodetic Observatory (MGO)

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We Welcome Collaborators!

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Abstract

Continuing upon the four-decade long heritage of space geodesy at UT's McDonald Observatory, NASA Space Geodesy Project and UT-Austin are collaborating on establishing the McDonald Geodetic Observatory (MGO). The MGO is intended to be a core geodetic site, to help realize the next generation 0.1 mm/year stable reference frame in accordance with the recommendations within the NRC Precise Geodetic Infrastructure (2010) report. The NASA SGP shall furnish the laser ranging (SGSLR), VLBI (VGOS), and the GNSS systems. UT-Austin furnishes the infrastructure, and contributes research instrumentation and experiments to integrate diverse metrological systems into a unified geodetic observatory. UT contributions include superconducting gravimeter for vertical control and gravity reference, mm-Metre receiver experiments for signal-level integration of techniques, environmental measurement and modeling experiments, and related metrological and modeling research efforts. This paper will present the status of the MGO, present the preliminary results from these experiments, and highlight the early lessons learned in establishing a fully integrated core geodetic site.

In Transition…

McDonald Observatory, Texas – Stable location representing the motion of the North American Plate.

Astronomy since 1939

Continuous positioning for 30+ years (MLRS late '80s, GPS early '90s)

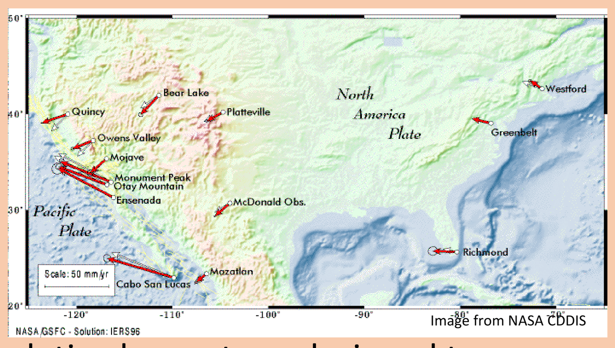
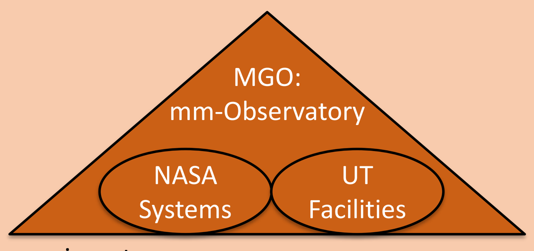


Image from NASA CDDIS

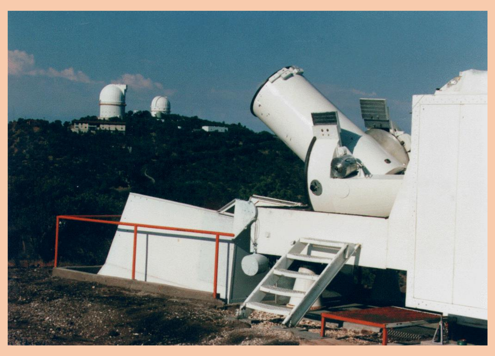
- MGO is a multi-technique geodetic observatory, designed to fulfill Next-Generation Reference Frame Requirements
  - principally driven by sea-level science
- For the foreseeable future (next decades), MGO will continue to be a core component of the Global Geodetic Observation System (GGOS).

The Partners in MGO



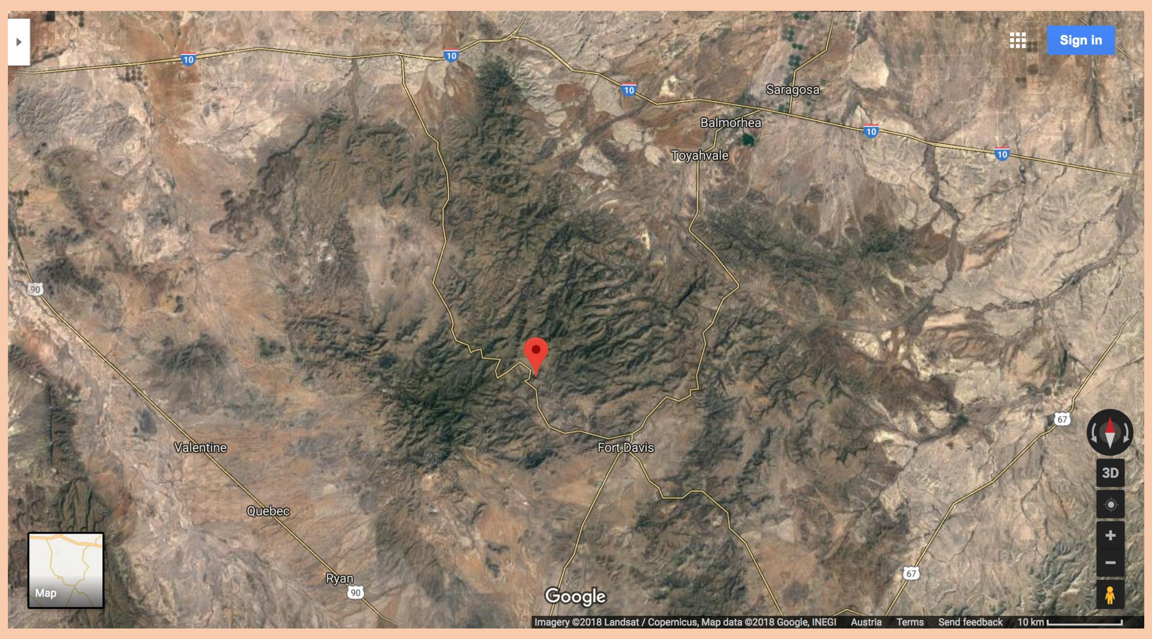
- The University of Texas at Austin:
  - Funds site preparation and infrastructure
  - Contributed instrument systems and research experiments
  - Sponsored research to support the full realization of the MGO
- NASA Space Geodesy Project (NASA/SGP):
  - Furnishes the space geodetic systems to be hosted at MCD;
  - Funds the staff to install/operate the VLBI & SLR.
- McDonald Observatory: Hosts new systems
  - A facility of UT-Astronomy/College of Natural Sciences
  - Satellite Laser Ranging at MCD started with LLR in 1969
  - Has been previously envisaged ('70s and '80s) as a fundamental site…
- Schedule
  - Infrastructure in place by late 2018
  - VLBI operational in 2019
  - SGSLR operation in 2020


12m VLBI Antenna (GSFC)

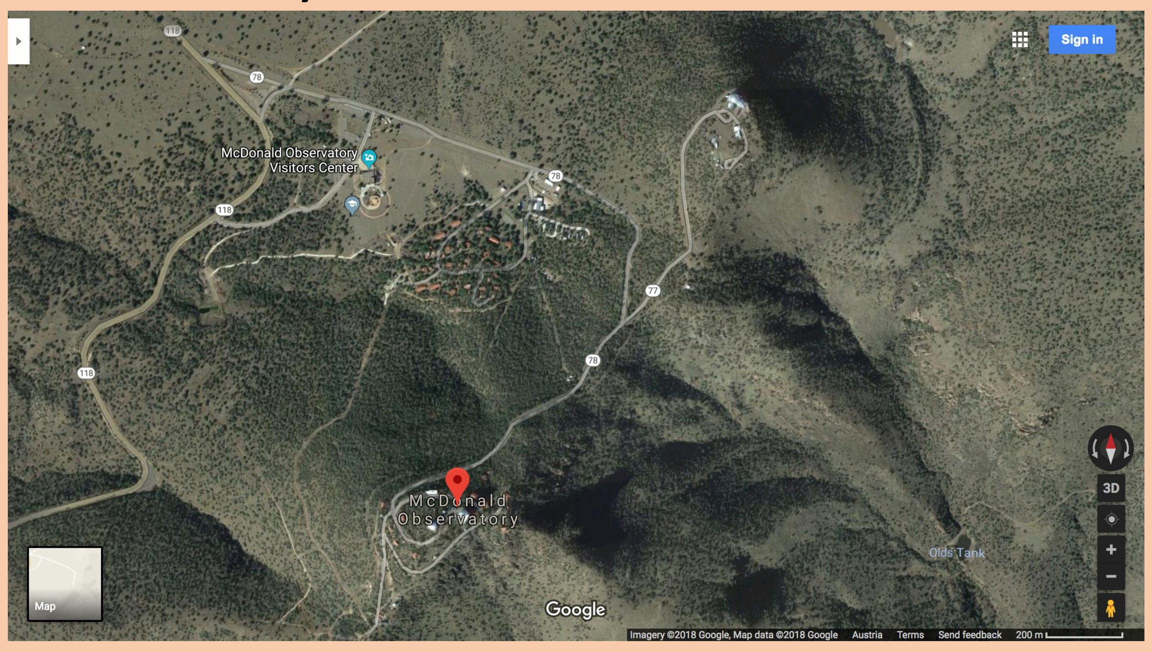

McDonald Laser Ranging Station (MLRS)


SGSLR Prototype (GSFC)

The Region (Arid, Mountainous, Sparsely Populated)

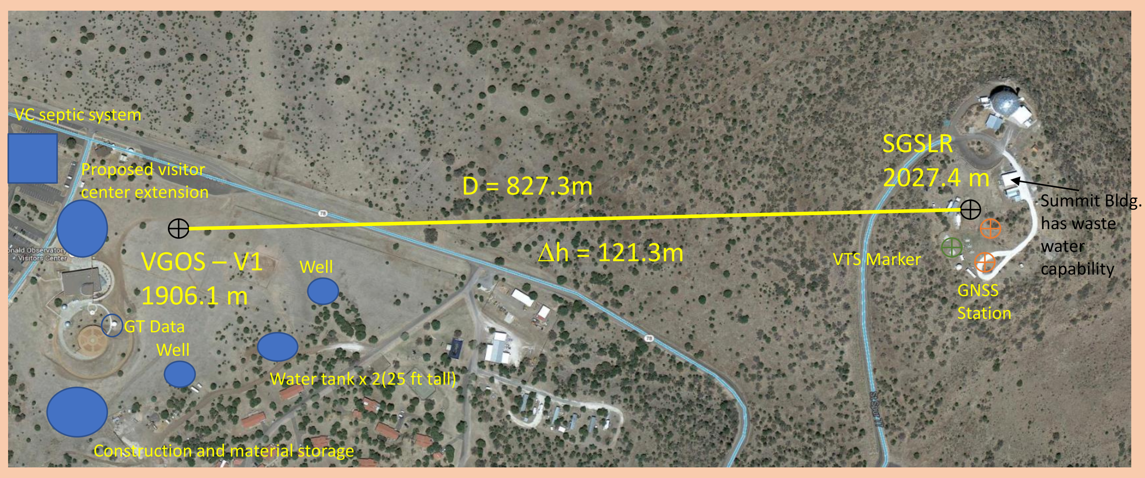


The Observatory



Infrastructure Layout

Status: Detailed design completed for infrastructure at Mt. Fowlkes and Visitor Center sites. Under construction.

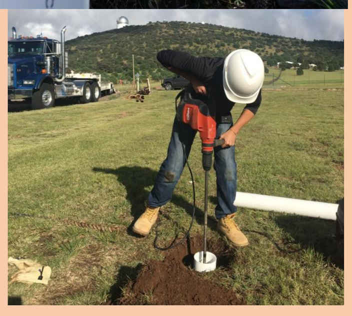


UT Co-experiments

1: mm-Metrology at MGO

- Principal Investigator: Bettadpur (UTCSR)
- Purpose: mm-Level ties between sites separated by ≈1-km horizontal and 120-m vertical separation, using both laser metrology and GPS
- Funding: NASA/ROSES-SGR
- Status @ June 21, 2018
  - Sub-mm horizontal and 2/3 mm vertical precision achieved over the baseline.
  - Metrology carried out separately with two Leica TS-30 and GPS.
  - Researching the use of meteorological profiling measurements along the light path to minimize vertical errors.
  - Accuracy-limiting factors identified, and algorithmic improvements being researched.

Graduate student Jullian Rivera (CSR)



2: Superconducting Gravimeter

- Principal Investigator: Clark Wilson, UT Jackson School of Geosciences
- Purpose: Vertical Control & Gravity Reference
- Funding: UT Austin
- Status @ June 21, 2018
  - Gravimeter hut is installed, and power & data lines completed
  - Facility ready for installation.
  - Installation awaiting end of SGSLR pad construction.

3: Quantifying dynamic water storage in soil and bedrock

Trees rooted directly into rock at the MGO suggest hydrologic loading could extend beyond soils, into fractured bedrock.

PROBLEM STATEMENT:
water storage measurement in fractured bedrock remains exceptionally challenging.

OBJECTIVE:
- Improve understanding of deep, bedrock water storage ("rock moisture") by using experimental and conventional tools to intensively monitor dynamic subsurface water storage.
- Help predict loading and gravity variations due to water cycle.

METHODS:
- Shallow (<30 cm) soil moisture monitoring via Time-Domain Reflectometry (TDR)
- Deep borehole logging (neutron, gamma, nuclear magnetic resonance)
- Surface electrical resistivity tomography and ground penetrating radar to quantify subsurface storage.

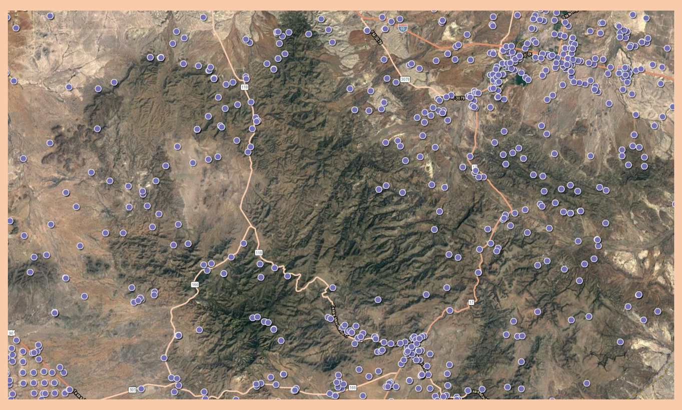
- Purpose: Quantify subsurface water storage dynamics
- Funding: UT ESI Billy Carr Fellowship
- Status - BNMR
  - Two holes drilled in vegetated area at Mt. Fowlkes
  - Monitored using borehole nuclear magnetic resonance (BNMR) to evaluate water storage (storm & dry conditions)
  - Preliminary assessment indicates high water storage capacity in upper 2 m, with little to no water stored in fractures.
- Status – Soil Moisture
  - Two locations at Mt. Fowlkes, each at 1 foot and 2-feet depth.
  - Upper probes shows diurnal soil-moisture variations.
  - Instruments will be calibrated to specific soil type onsite.

Two monitoring boreholes drilled by UNAVCO

Graduate student Logan Schmidt

4 : Regional Water Cycle Characterization

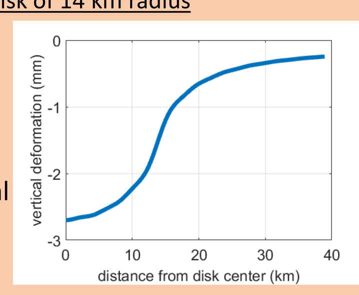
Candidate well locations in Davis Mountains



Total water storage estimation

- Ground Water: Well level time-series
- Soil Moisture: Network of CS655 probes
- Surface Water: Precipitation and Stream gauges

Deformation due to a 1-m thick water disk of 14 km radius



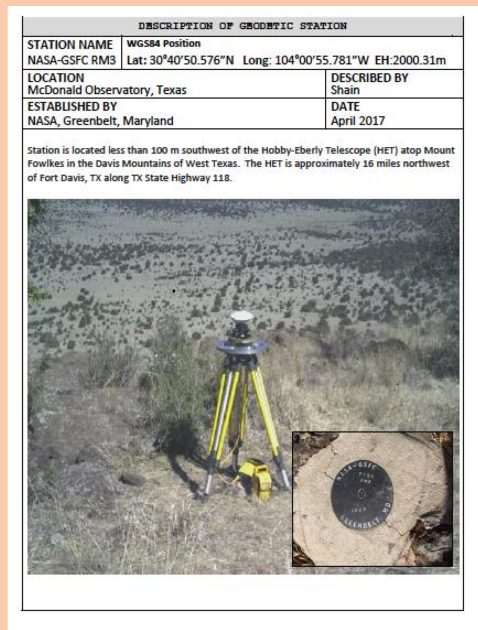
Todd Caldwell (UT-JSG) NSF-funded study on ephemeral recharge in trans-Pecos spring complex; part of larger project on regional groundwater flow system

Average annual precip: 45 cm

5: Deflection of the Vertical

- Principal Investigator: Clark Hughes, UT Applied Research Laboratory
- Purpose: Development and testing of high-precision Deflection of the Vertical cameras.
  - Could support improved realization of the horizontal at the MF and VC sites.
- Funding: NGA (ARL Texas Astro Project)

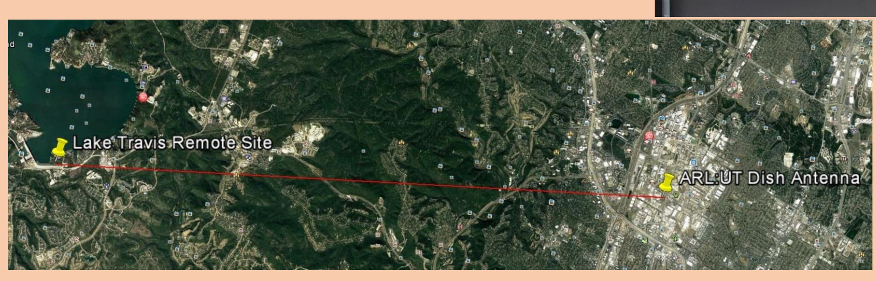
- Status @ June 21, 2018
  - DoV camera prototype developed and tested in previous programs at UT:ARL facilities.
  - A35M Astrolabe survey completed at Mt. Fowlkes in April 2017.
  - Requested re-survey of Mt. Fowlkes and Visitor Center sites with the DoV camera.



6: Celestial Sources through GNSS signal chain

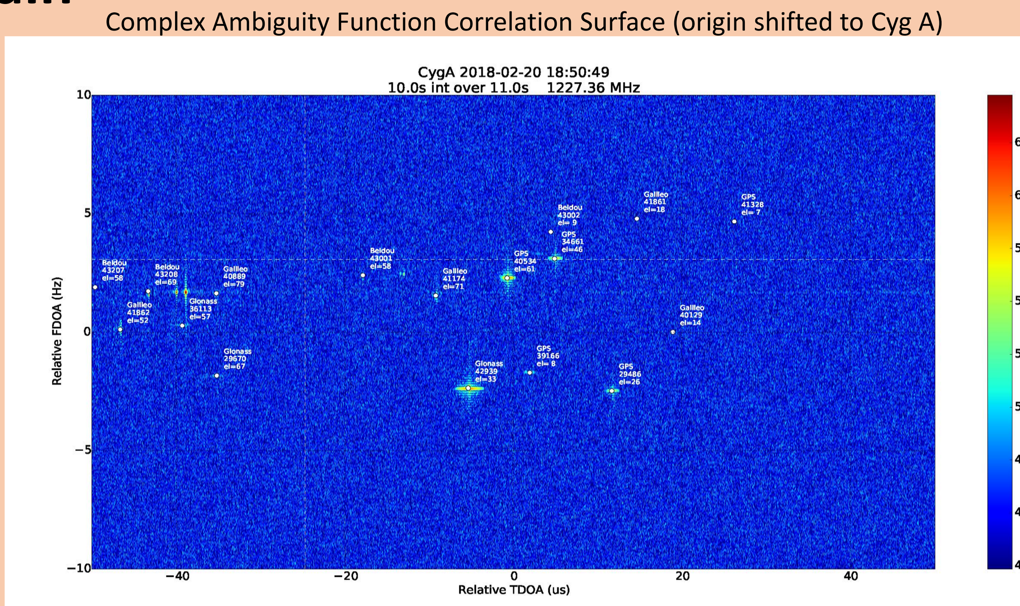
High Rate Tracking Receiver
–Variety of scientific/engineering uses
–Direct-to-Digital Receiver
–Characteristics
- 3 band configurations
  - –0.1-1 GHz, 1-2 GHz, 2-3 GHz
- 1 GHz instantaneous direct sample bandwidth
- FPGA-based digital downconversion and processing
- Minimal analog front-end to minimize biases

Experiment (NASA/ROSES-STMD):
- 16 km baseline established
- Spectral data being collected daily
- Currently collecting observations, testing processing algorithms



16 km baseline

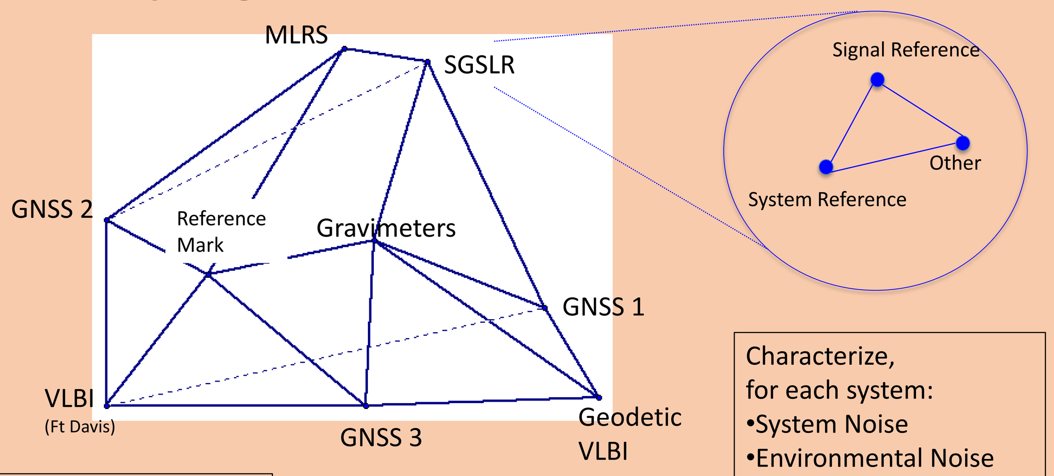
Complex Ambiguity Function Correlation Surface (origin shifted to Cyg A)



20 Feb 2018 Target: Cyg A, 10s Integration test – 3-m dish and GNSS choke ring
Marginal integration time for this target

Expected Results

Developing the Frameworks

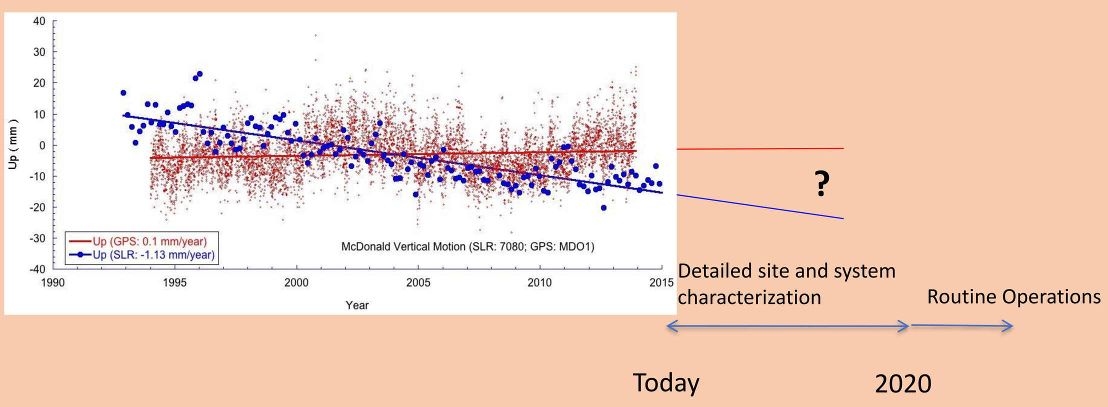


Characterize, for each system:
- System Noise
- Environmental Noise
- Analysis Noise

Time-variable Polygon:
- Measurement
- Characterization
- Application

Define & monitor a dynamic polygon framework

Key Outcomes



Outcomes by 2020:

- Demonstrate that MGO is a mm-Observatory
- Establish the framework for using MGO and similar observatories for TRF
- Develop skilled cadre of staff and scientists

Construction Progress

As of 8 October, 2018


MGO SGSLR with MLRS in background


MGO VLBI Pad and Assembly Area with McDonald Visitors Center