Gilmore Creek Site Baseline Report

Report Prepared for the Goddard Space Flight Center Space Geodesy Project Code 690.2

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1.0 Acknowledgements

The authors would like to thank the following people for their extensive knowledge and information that contributed to the writing of this report. They include: Larry Ledlow, George McAulay, and Roger Kermes at the Gilmore site, Julie Horvath and Felipe Hall from Honeywell Technology Solutions Inc., and Michael Floyd and Robert King from MIT.

One component that is necessary for the success of NASA's Space Geodesy Project is the identification of key locations to populate the next generation space geodesy techniques to form a Fundamental Station. As part of the process, a baseline of each occupied NASA SLR and VLBI site and a few key GPS sites will be compared with the site criteria to determine viability for a Fundamental Station. This baseline information will then be used to evaluate other potential sites. With significant help from the above referenced people we were able to accumulate much of this information into a report that will help determine the next NASA Space Geodesy Network.

2.0 Executive Summary

One of the tasks under the NASA Space Geodesy Project (SGP) is to identify candidate locations for the new Fundamental Stations. A Fundamental station is one that ideally consists of the following space geodesy techniques, a next generation satellite laser ranging (NGSLR) ground system, a next generation very long baseline Interferometry (VLBI-2010) system, and an updated Global Navigation Satellite System (GNSS) ground system that has the capability to receive data from all GNSS satellite constellations. If a Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) system is also included, it would be an advantage. The requirements for this Fundamental Station can be found in the document, "*Site Requirements for GGOS Fundamental Stations*, 2011": (http://cddis.gsfc.nasa.gov/docs/GGOS_SiteReqDoc.pdf)

The initial requirement of this project is to baseline the current NASA SLR, VLBI, and select GNSS sites to the requirements stated in the site requirement document. As NASA has a rich history of sites with 1 to all 4 techniques collocated, a baseline of each NASA site will allow for a better understanding of what existing and new sites will meet with the SGP requirements.

The sixth NASA owned and operated site to be baselined as part of the SGP is the Gilmore Creek Geophysical Observatory (GCGO) in Alaska. GCGO is located in central Alaska approximately 16km (22km by road) northeast of Fairbanks. Access from Fairbanks to the site is via Steese Highway then Eisele Road. The site sits a approximately 319 meters and experiences sub-arctic weather conditions. Skies in the region are typically mostly cloudy to overcast 75% of the time, clear 25% of the time during February, March, and April, and clear 10-15% of the time during the rest of the year.

The GCGO site is located within a federal land withdrawal that sets aside 8500 acres (3439 hectares) to support the GCGO. The land withdrawal was renewed in 2009 for 20 years. Currently, GCGO facilities cover approximately 100 hectares of the land withdrawal with space for additional facilities.

Currently, the only space geodetic technique operating at the site is the GNSS antenna, CORS station FAIR. VLBI and DORIS have operated at the site in the past.

Other site infrastructure including power, safety, security and access are all very good. For communications, there are network connections of various types, including fiber optics. Power generators and fuel storage on site can keep the site powered up for several weeks in the event of an extended commercial power outage.

Geologically, the site is located in a tectonically active region with influences from a subduction zone, strike-slip fault systems, glacial retreat, and local precipitation. The site is located in a tectonically active area of central Alaska. Although the site has small uncertainties on horizontal velocities (0.1 mm/yr), it is influenced by elastic strain accumulation associated with the NA-Pacific plate subduction boundary, active strike-slip fault systems in the “back-arc”, and postseismic motions from the Denali earthquakes. Large vertical motions due to postglacial isostatic adjustment (few mm/yr), and elastic loading associated with glacial retreat and annual snow and rainfall are likely. This location will require detailed monitoring and modeling of tectonic, isostatic, and elastic motions in order to meet GGOS stability requirements.

Areas of concern include the effects of the seismically active region and the history of large (mag>7) earthquakes. Also, as this is an antenna farm, a detailed RFI study would need to be performed to identify RFI issues. Also, identification of a suitable VLBI2010 and NGSLR facility with RFI impacts needs to be further studied. Also, as the local gold mine continues to encroach on the GCGO facility, impacts of the mining operations to site stability need to be considered. Further, the potential extreme cold weather and the prolonged daylight hours of the summer need to be considered in the NGSLR operations concept for extreme cold weather operations and lack of starcal alignments for extended periods of time.

Things that need to be completed for this site include the following:

1. Completion of an RFI Study for broadband.
2. Local hydrology (well levels, aquifer characteristics) and relationship to apparent vertical site stability.
3. Inclusion of a local and regional tie maps.
4. Improved cloud coverage data.
5. A better understanding of the surrounding elevation limits to meet the low elevation requirements for each of the techniques.
6. Identification of a usable VLBI2010 site either close to the existing compound or within the larger gated area.
7. Identification of a usable NGSLR site that would provide adequate sky coverage in elevation and shielding of the NGSLR LHRS

In summary, the Gilmore Creek site has a long time series for VLBI and GNSS. Weather at the site is generally good but the extremes in cold and daylight may be a potential issue to be resolved for the NGSLR system. There is also an issue with cloud cover. Finding a suitable location for both the VLBI2010 system and the NGSLR will need to be further examined as well as detailed cloud studies and RFI mapping. Other site infrastructure and local commitment are excellent and the site would be ideal for polar orbiting satellites with the high latitude. Site stability is a concern with the site prone to seismic activity, necessitating further geological study to be performed.

3.0 Introduction – Gilmore Creek Site Conditions for GGOS

This report describes the current conditions at the Gilmore Creek site in Alaska that will determine the suitability of the site as a Fundamental Station for geodesy as described in the paper *Site Requirements for GGOS Fundamental Stations*, 2011. The information provided below will also provide a basis for comparison with other candidate sites during the site selection process.

The key elements that make up a Fundamental Station include a Next Generation Satellite Laser Ranging (NGSLR) system, a broadband capable Very Long Baseline Interferometry (VLBI2010) system and a Global Navigation Satellite System (GNSS) capable system. A DORIS system is desirable to the success of the Fundamental Station but is subject to the plan of the DORIS network.

The following sections will examine all of the components of the Site Requirements for a Fundamental Station and will provide a summary of this examination. While NASA has occupied these initial locations by either SLR, VLBI, GNSS, or combinations of 2 or all three techniques, no site is to be considered as an exact candidate for a Fundamental Station. Also, it is understood that none of the existing sites is an exact match to the requirements. Ideally, the requirements within the *Site Requirements for GGOS Fundamental Stations* would make the best site; however, there is probably not an existing NASA occupied site that meets all of the criteria. This report just provides a baseline of the existing sites and allows for an informed decision by the Space Geodesy Project (SGP) to make the next choices for a Fundamental Station.

4.0 Existing Techniques

The only technique currently active at the Gilmore Creek site is GPS.

VLBI – VLBI is not currently on site. VLBI previously occupied the site from 1979 to 2010.

GNSS - A GPS antenna/receiver was installed at IGS station FAIR in 1991.

IGS FAIR Station

Domes: 40408M001 PID: AF9535 Code: FAIR

IGS FAIR Station, December, 2012, Looking Southeast

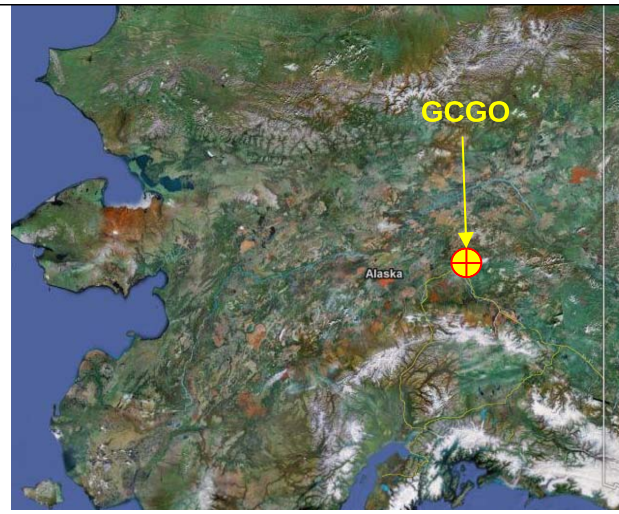
Domes: 40408M001 PID: AF9535 Code: FAIR

DORIS –. DORIS is not currently on site. DORIS occupied the site previously between 1990 and 2010.

SLR – SLR is not currently of site.

5.0 Global Consideration for the Location

The Gilmore Creek GCGO site is located northeast of Fairbanks in central Alaska.

Gilmore Creek on North American Continent	
Continental Context	Gilmore Creek Region
	

5.1 Geometrical Distribution

The Gilmore Creek Geophysical Observatory is located in eastern central Alaska at 65N latitude. The location provides coverage at high latitude for various techniques.

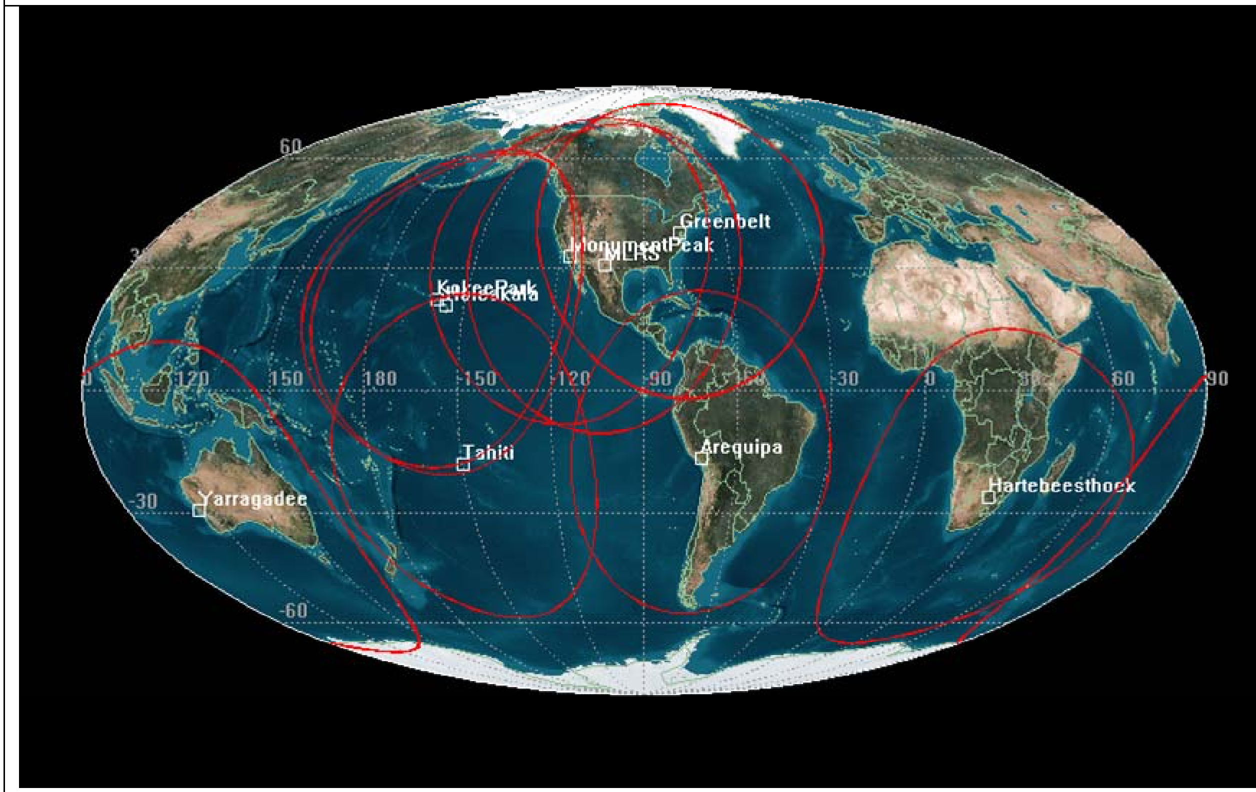
5.2 Technical Distribution

It is desired to have three well distributed stations on each tectonic plate. GCGO is located within the North American tectonic plate at a north latitude of 65 degrees.

5.3 Technique Dependent Distribution

The northerly location of the Gilmore Creek site near Fairbanks, Alaska, would provide coverage for satellite tracks at high latitude. The following plot displays the tracking coverage down to 20 degrees elevation for LAGEOS by the existing NASA SLR sites.

20 Degree Acquisition for Lageos by NASA SLR Sites



6.0 Geology

See the report from MIT on the stability of the Gilmore Creek site included at the end of this document in Appendix A.

6.1 Substrate

See the report from MIT on the stability of the Gilmore Creek site included at the end of this document in Appendix A.

6.2 Tectonic Stability

A report from MIT on the stability of the Gilmore Creek site is included at the end of this document in Appendix A.

7.0 Site Area

The Gilmore Creek site is located at an approximately 16km line of sight distance northeast of Fairbanks, Alaska, at an elevation of 319 meters. The city of Fairbanks has a population of ~32000, and has nearby civilian and military airfields.

Gilmore Creek Site Region

Source: http://www.bing.com/maps/

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Gilmore Creek Site Region

Source: http://maps.google.com/maps?hl=en&tab=wl

Gilmore Creek Site

Source: http://www.bing.com/maps/

Main Complex

Source: http://www.bing.com/maps/

Southern Complex

Source: http://www.bing.com/maps/

VLBI Area

Source: http://www.bing.com/maps/

Gilmore Creek Site

Note: Looking East

VLBI From Southwest

7.1 Local Size

The GCGO is located within a mostly undeveloped area of 3439 hectares. The developed site is laid out in two long fingers and one short one that span an area of approximately 100 hectares.

Gilmore Creek Site

Source: http://www.bing.com/maps/

Gilmore Creek VLBI Area

Source: http://www.bing.com/maps/

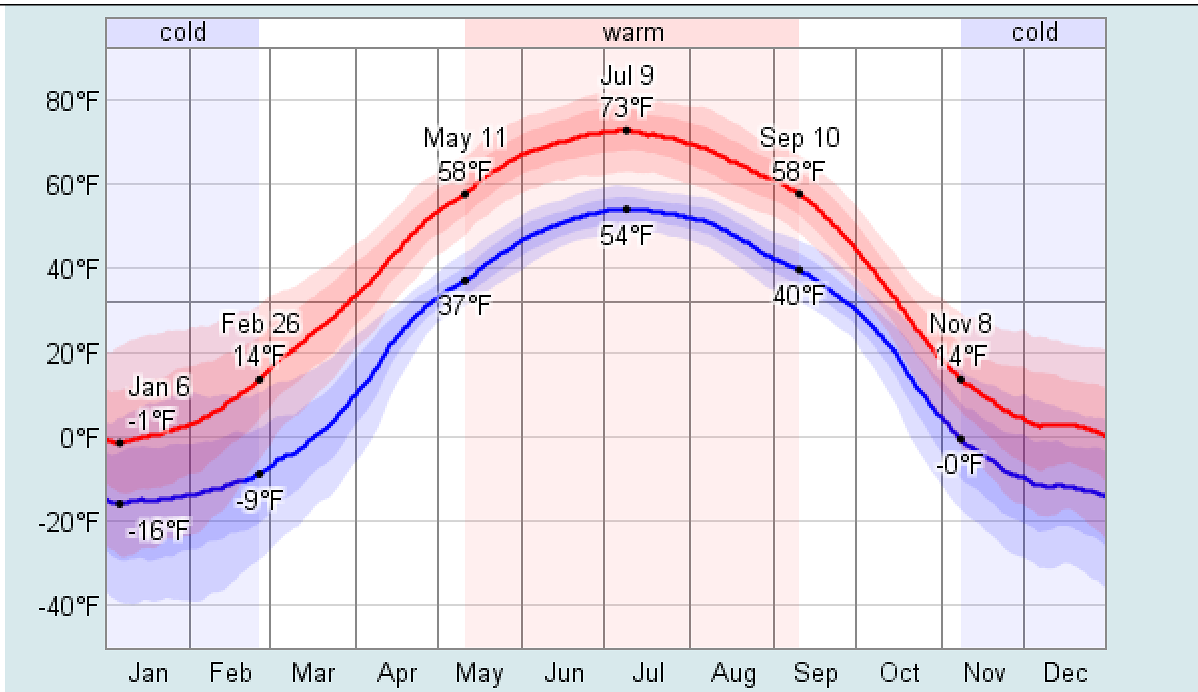
7.2 Weather & Sky Conditions

7.2.1 Climate

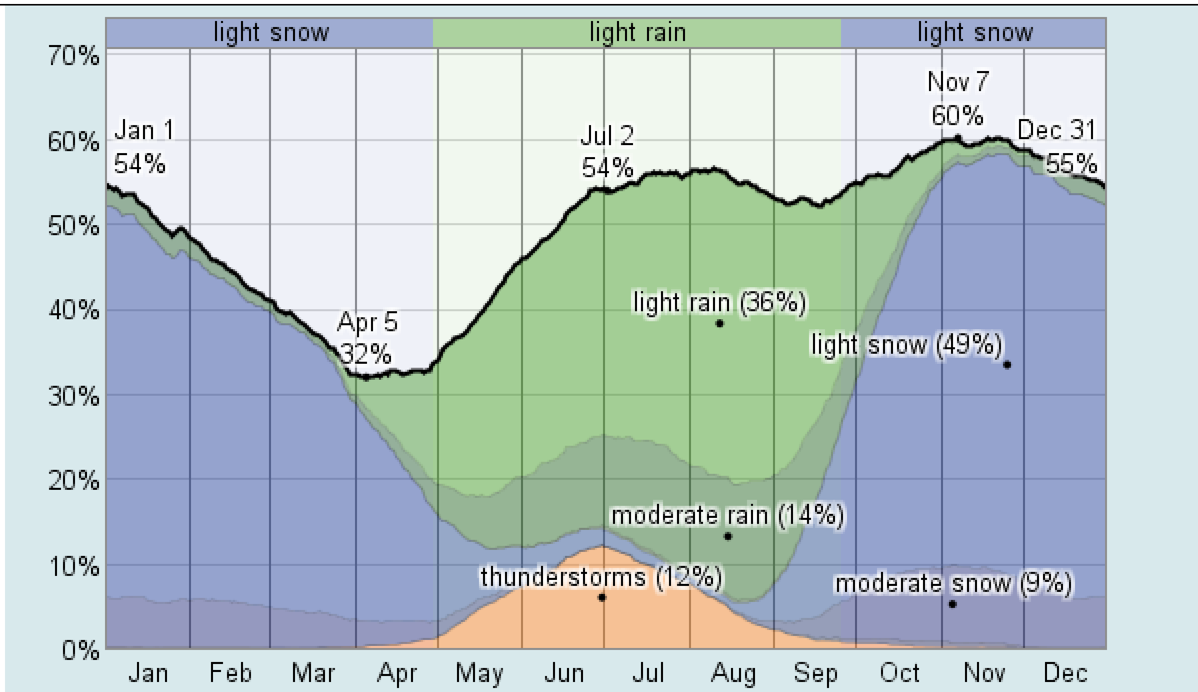
Climate in the region of the GCGO is subarctic.

The following links, accessed in October, 2012, provide plots of weather data for Fairbanks International Airport and Eielson Air Force Base:
http://weatherspark.com/averages/32940/Fairbanks-Alaska-United-States (Fairbanks Int.)

Fairbanks International Airport Average Temperatures



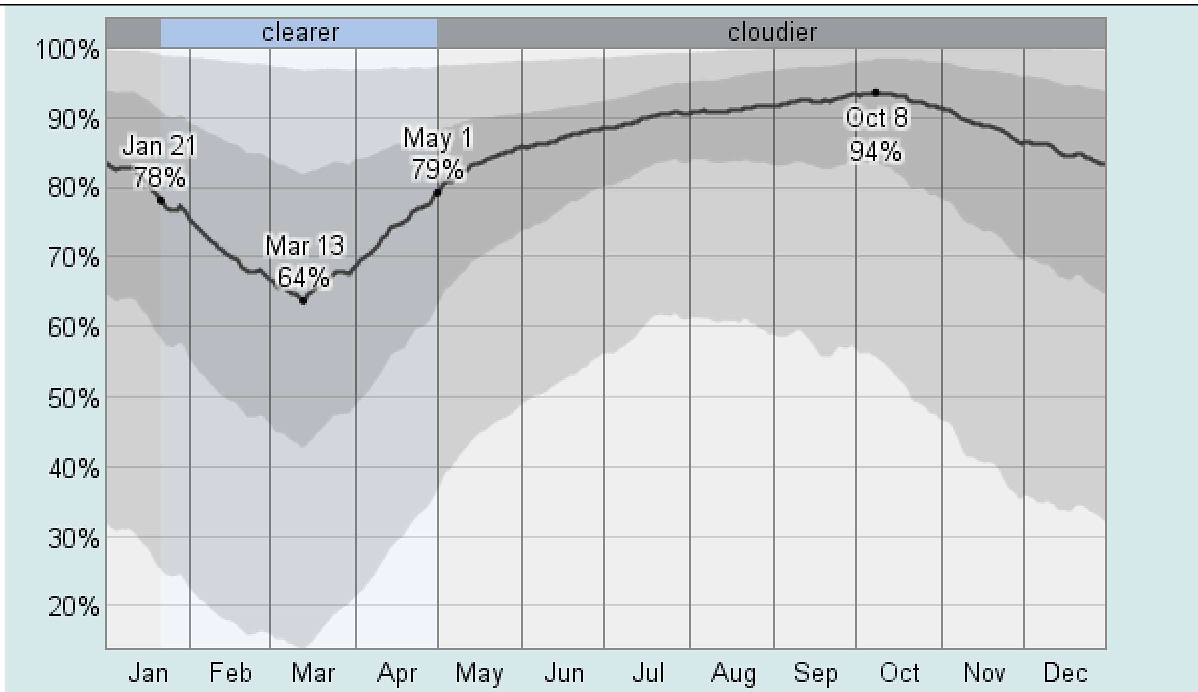
Source: http://weatherspark.com/averages/32940/Fairbanks-Alaska-United-States

Fairbanks International Airport Average Precipitation Probabilities

Source: http://weatherspark.com/averages/32940/Fairbanks-Alaska-United-States

http://weatherspark.com/averages/32935/Fairbanks-Alaska-United-States (Eielson AFB).

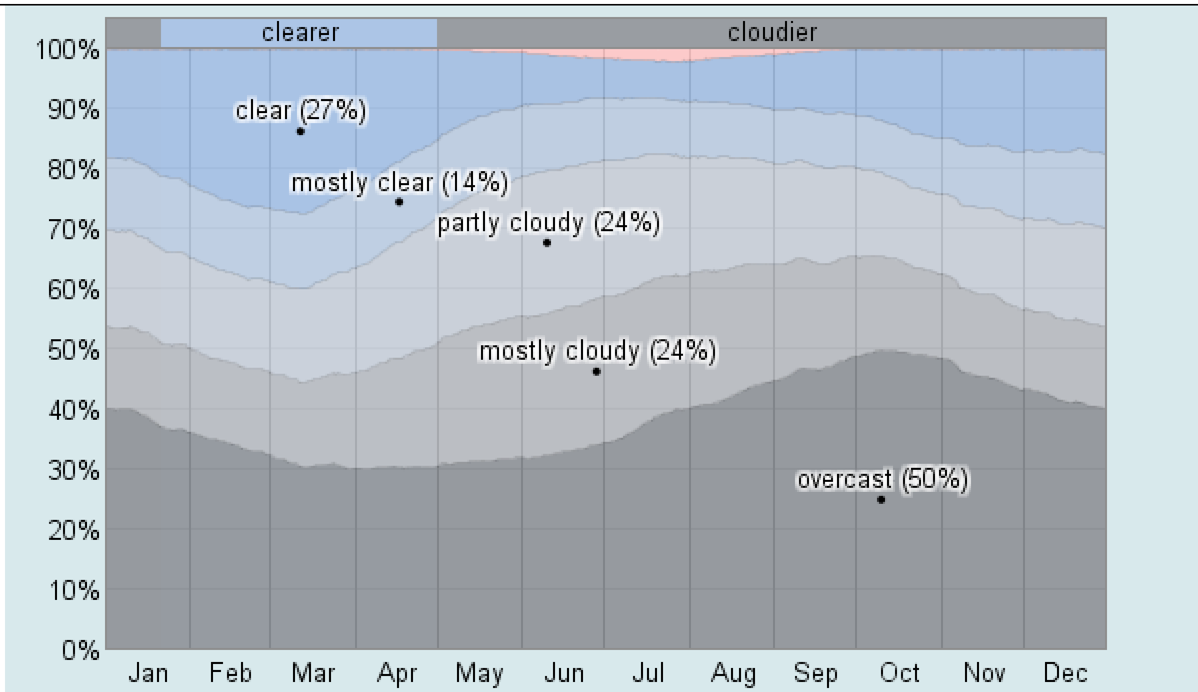
7.2.2 Sky Conditions

Fairbanks International Airport Median Cloud Cover



The median daily cloud cover (black line) with percentile bands (inner band from 40th to 60th percentile, outer band from 25th to 75th percentile).
Source: http://weatherspark.com/averages/32940/Fairbanks-Alaska-United-States

Fairbanks International Airport Cloud Cover Types



The fraction of time spent in each of the five sky cover categories. From top (most blue) to bottom (most gray), the categories are clear, mostly clear, partly cloudy, mostly cloudy, and overcast. Pink indicates missing data. Outside of the United States clear skies are often reported ambiguously, leading them to be lumped in with the missing data.
Source: http://weatherspark.com/averages/32940/Fairbanks-Alaska-United-States

7.3 RF and Optical Interference

7.3.1 RF Interference

In 2000 the Joint Spectrum Center (JSC), at the request of NOAA, performed an electromagnetic environment (EME) survey and RFI assessment for the Fairbanks Command, Data, and Acquisition Station (FCDAS) at the Gilmore Creek site. The task included assessments of impacts from nearby mining activities, urban expansion, registered systems in the vicinity of FCDAS, and the effectiveness of terrain shielding.

Mining operations, as they existed in 2000, were found to be a source of RF emissions, but not at a magnitude large enough to impact FCDAS operations. Mining operations have continued to expand toward the site. The study recommends that distances between pit mining operations and antennas at the site be kept as large as possible, and that RF welding and plasma torch usage be banned in those pit mining sites. Another factor is a mine access road adjacent to the site that may be a source of RFI and vibration from mining vehicles.

During a line of sight analysis, the 26m and 13m antennas were determined to be exposed to signals originating from sources along Steese Highway and Eisele Road. The magnitude of the signals, mostly in the HF/VHF/UHF frequency bands, is expected to increase as traffic levels increase in the future.

Modification of the contours of the Gilmore Dome would have a negative impact on the terrain shielding the RFI environment of the Gilmore Site.

7.3.2 Optical Interference

GCGO is relatively remote, with some minor light pollution from Fairbanks to the southwest and some mining operations to the east. There are lights illuminating the antennas and other facilities on the site.

During the summer the days are very long with the longest day lasting approximately 21:45 hours. The northern sky remains in twilight overnight. The 65 degree north latitude of GCGO places the site under occasional displays of the Aurora Borealis. Green auroral displays emit primarily at the 557.7nm Oxygen line.

7.3.3. Other Possible Interference

Mining activities and mining vehicles traveling on access roads adjacent to the site may be a source of vibrations.

7.4 Horizon Conditions

The *Site Requirements for GGOS Fundamental Stations* document states that, ideally, stations should have an obstruction free view down to 5 degrees elevation over 95% of the horizon.

At the Gilmore Creek site, as with any site, horizon conditions for each technique will vary depending on the location and height of each technique on the site. For SLR, the radar of the Laser Hazard Reduction System (LHRS) used for aircraft protection works best with a clear horizon within 400 meters free of trees, buildings, towers, and other tall objects that would contribute to ground clutter.

A determination for a VLBI2010 site needs to be made prior to finalizing the horizon conditions for such a station.

West View from VLBI Parking Lot


Northeast View from VLBI Parking Lot


Southeast View from VLBI Parking Lot

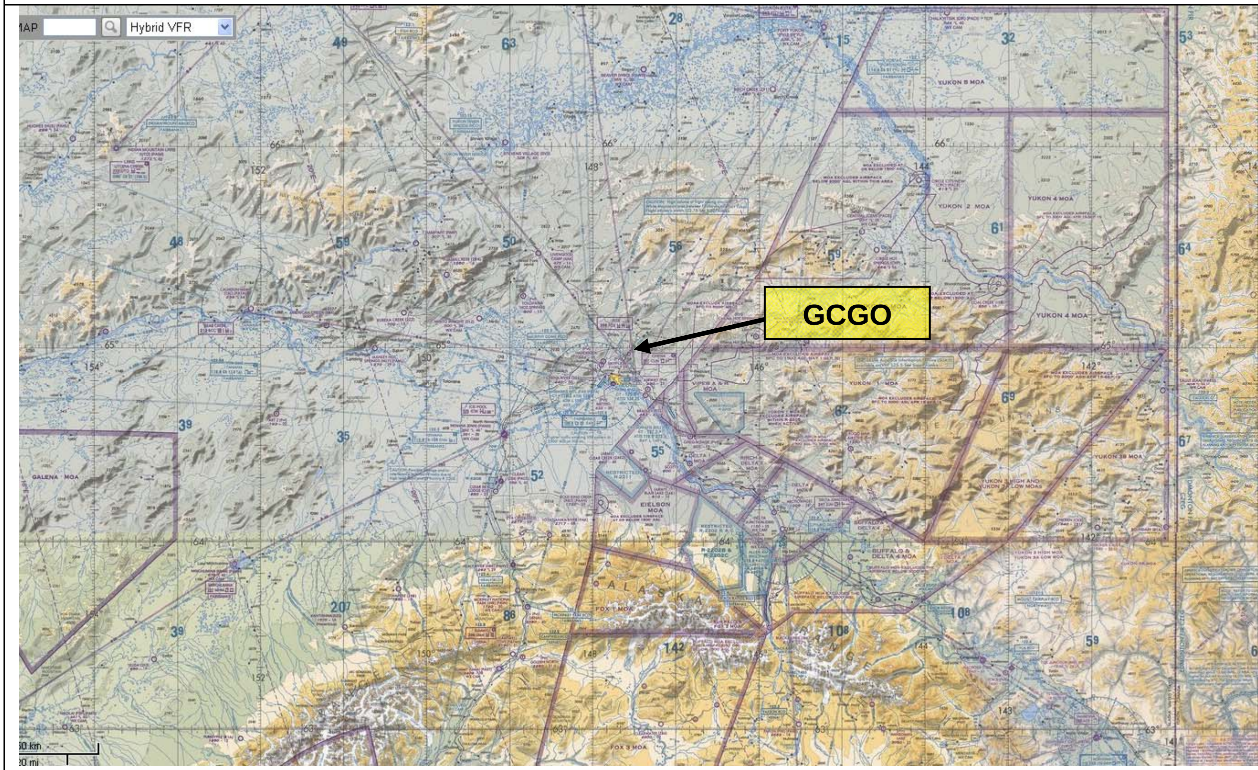

7.5 Air Traffic

The nearest major public airport is Fairbanks International Airport located on the west side of Fairbanks. General aviation by small, privately owned aircraft that takeoff and land on lakes or small, unpaved airstrips is possibly the major component of air traffic in the region.

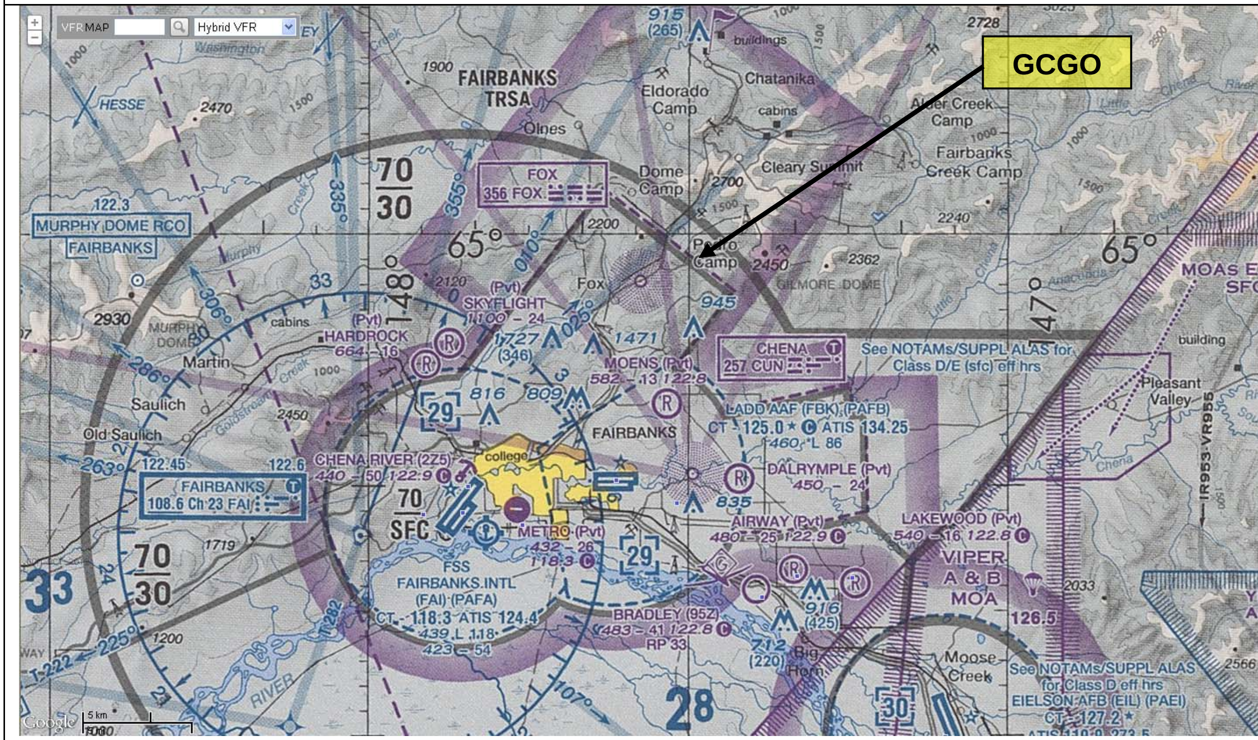
The following is from the Fairbanks International Airport website:

"Per Capita, there are more private pilots in Alaska than anywhere else in the United States. Fairbanks International Airport is proud to serve as the second largest multi-use airfield in the state. Our facilities, capacity and maintenance are second to none. Pilots have their choice of two runways- one is gravel and the other paved- of 2,900' x 75' and 6,500'x 100 feet, respectively. Our float pond has a 5,400' x 100' landing surface. We have 322 tie downs and 228 float pond spaces." (Source: http://dot.alaska.gov/faiiap/genavsvcs.shtml)

On the east side of Fairbanks there is the Ladd Army Airfield, and to the southeast of Fairbanks and SSE of GCGO there is the Eielson Air Force Base.

Flight Navigation Chart For Gilmore Creek Region

Source: http://vfrmap.com/

Airports in the Gilmore Creek Region



Source: http://vfrmap.com/

7.6 Aircraft Protection

For SLR, a HTSI Laser Hazard Reduction System (LHRS) automatically detects aircraft approaching the laser beam transmit path and blocks the laser transmission until the path is clear of aircraft. It is the current method of aircraft hazard avoidance at many of the NASA SLR sites.

7.7 Communications

There are DS3, OC3, and many T1 lines supporting the site. Major fiber infrastructure upgrades have been installed throughout the site including the old VLBI site.

7.8 Land Ownership

The land is managed by the Bureau of Land Management under a federal withdrawal covered by Public Land Order (PLO) 3708 modified by PLO 6709. The withdrawal lasts until 2029, and withdraws “approximately 8,500 acres of public land from settlement, sale, location, or entry under the general land laws, including the United States mining laws, to protect the Gilmore Satellite Tracking Station.” (Federal Register/Vol. 72, No. 21/Thursday, February 1, 2007/Notices).

7.9 Local Ground Geodetic Networks

7.9.1 Local Station Network

DOMES markers at Gilmore Creek GCGO:

DOMES No.	Description	Code
40408M001	GPS Pillar	FAIR
40408M002	Range building roof / engraved cross on aluminum (DORIS 1 mark)	
40408M004	Engraved cross on upper surface of a 6-meter pedestal	
40408S001	26m antenna reference point	
40408S002	26m VLBI ref. point (GILMORE CREEK)	7225
40408S003	Rogue SNR-8/DM R/L 1 17-JAN-91	
40408S004	DORIS antenna ref. pt (Alcatel type)	FAIA
40408S005	DORIS 2 antenna ref. pt. (Starec type)	FAIB
Source: ITRF website http://itrf.ign.fr//site_info_and_select/site.php		

Listing of markers from the NGS website centered on CORS station FAIR:

```
|Dist|PID...|H V|Vert_Source|Latitude.....|Longitude.....|Stab|C|Designation
|----|------|- -|-----------|-------------|--------------|----|-|-----------
| 0.0|AF9535|A .|88/GPS OBS.|N645840.79460|W1472957.15809|....| |GILMORE CREEK CORS MONUMENT
| 0.0|UW8029|0 .|29/GPS OBS.|N645841.36318|W1472953.97765|D...|G|GILMORE CREEK DOP 30067
| 0.0|AF9534|A .|...........|N645840.79460|W1472957.15809|....| |GILMORE CREEK OBS CORS ARP
| 0.0|AB6377|A .|...........|N645840.79462|W1472957.15812|....| |GILMORE CREEK OBS CORS L1 PHASE
CENTER
| 0.0|DK6557|A .|...........|N645840.79462|W1472957.15812|....| |GILMORE CREEK OBS CORS L1 PHASE
CENTER
| 0.0|UW8058|0 .|88/GPS OBS.|N645840.79904|W1472957.16376|C...|O|GILMORE VLBI
| 0.1|UW7917|2 .|29/GPS OBS.|N645842.32103|W1472940.46542|D...|G|FAIRBANKS NCMN
| 0.1|UW7929|0 .|88/GPS OBS.|N645842.18329|W1472940.72112|B...|G|FAIRBANKS NCMN
| 0.1|DH4861|0 .|88/GPS OBS.|N645842.28017|W1472940.67150|D...|G|GILCREEK NCMN 2
| 0.1|UW7915|A .|29/GPS OBS.|N645842.27862|W1472950.95883|D...|S|GILMORE CREEK MON 7225
| 1.3|TT2824|. 1|88/ADJUSTED|N645858......|W1473237......|C...|X|K 13
| 1.5|TT2825|. 1|88/ADJUSTED|N645923......|W1473225......|C...|G|C 53
| 1.5|TT2823|. 1|88/ADJUSTED|N645830......|W1473302......|C...|X|M 53
| 1.7|TT2826|. 1|88/ADJUSTED|N645949......|W1473211......|C...|G|L 13
| 1.9|TT2816|. u|29/ADJ UNCH|N645824......|W1473347......|C...|X|J 13
| 2.1|TT3205|. 1|88/ADJUSTED|N650027......|W1473051......|C...|G|M 13
| 2.5|TT2820|. 1|88/ADJUSTED|N645804......|W1473456......|C...|N|L 53
| 2.6|TT3206|. 1|88/ADJUSTED|N650053......|W1472925......|C...|X|N 13
| 2.8|TT6689|3 .|29/VERT ANG|N645956.07524|W1473445.38362|D...|G|FOX GLO USGS 1910
| 2.8|TT2815|. u|29/ADJ UNCH|N645808......|W1473535......|C...|G|H 13
| 3.0|TT6688|3 .|29/VERT ANG|N645911.13956|W1473555.77115|D...|G|FOX POINT GLO USGS 1910
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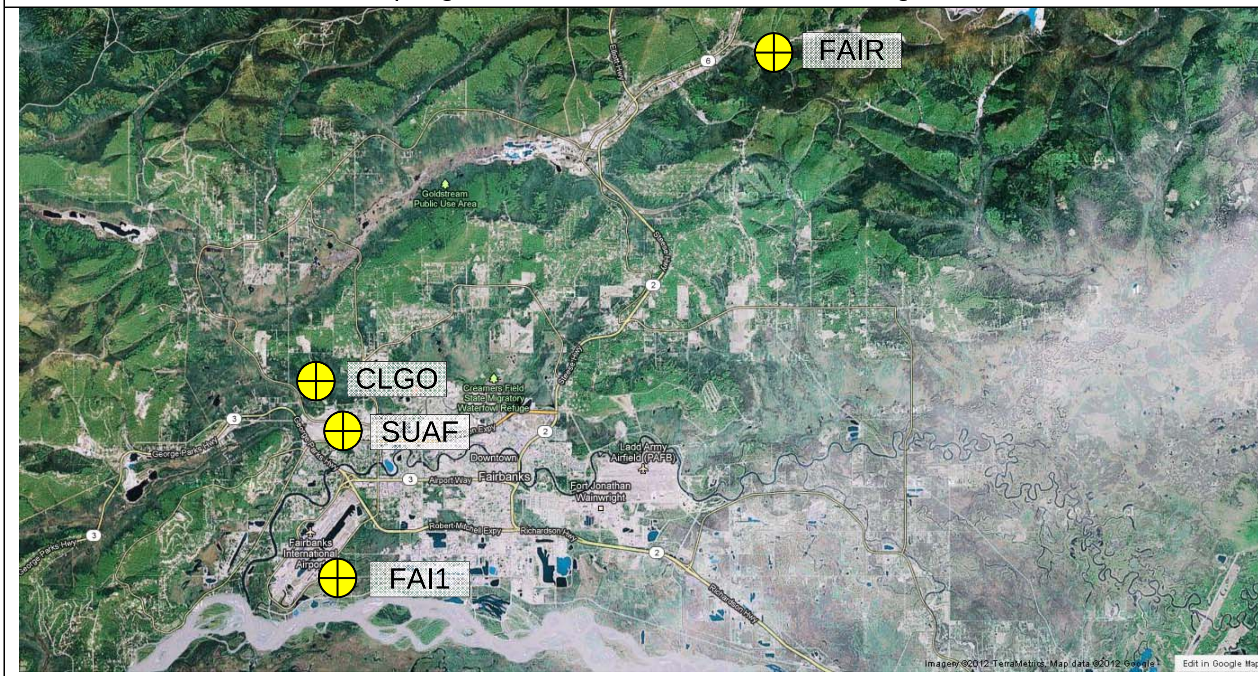
Sampling of Geodetic Markers

Source: http://www.bing.com/maps/

7.9.2 Regional Network

FAIR is a CORS station and an IGS reference frame station, DOMES number 40408M001, PID AF9535.

Sampling of CORS Stations in the FAIR Region



Map Source: http://maps.google.com/maps?hl=en&tab=wl
CORS Source: http://www.ngs.noaa.gov/CORS/GoogleMap/CORS.shtml

7.10 Site Accessibility

By road, GCGO is 22km away from Fairbanks. From Fairbanks the site is accessed via Steese Highway (Rt. 2, I-A2), Steese Highway (Rt. 6), and Eisele Road. Eisele continues past a guard shack onto the site.

Site access is good year round with an occasional ice storm being the only significant hazard. The site has never been closed due to bad weather. There have been only two requests in the past ten years for non-essential personnel to remain home due to icy conditions.

7.11 Local Infrastructure and Accommodations

Typical drive times to and from the site for site personnel are 20 – 30 minutes. Nearby Fairbanks, the second largest city in Alaska with a population of ~32000, is the major population center in the central region of Alaska. It has all of the utilities, municipal services, and healthcare facilities typical of a U.S. city of that size, arguably more due to its isolation. Most local internet providers offer fiber connections.

7.12 Electrical Power

Commercial power is obtained from the Golden Valley Electric Cooperative. The UPS system can power the site for 20-40 minutes. In the case of a long power outage, there are three generators that can power the site for several weeks with 60,000 gallons of fuel stored on site. Fuel is obtained from several vendors through the Defense Logistics Agency.

7.13 Technical and Personnel Support

There are a number of personnel with technical expertise currently working at the site to support NASA and NOAA programs.

The level of support suggested by the *Site Requirements for GGOS Core Sites* document is that the site will require a senior technician, eight shift technicians (2 per shift), a logistics and administrative officer, and a custodian.

7.14 Site Security

Security at the Fairbanks Tracking Station consists of security guards, locked entryways, video monitoring, limited access and remote location, all of which limits public and private access. Two Security Guards are on duty at the site's front gate during regular working hours from 0600 to 1800 hours. The security guards monitor and record access to the station, and perform roving patrols to check buildings systems and ground control. 22 video cameras are placed around the site in key locations. Video is monitored in the Guard Shack and in the Operations area. The On-Shift Operations Leader (present on-site 24/7/365) is responsible for security during those periods that Security Guards are not scheduled to work.

The station is gated and fenced, and additional fencing is provided around key areas. The supply yard, tracking antennas, and the cable tray going to the antennas are fenced. The front gate and doors in all buildings (and certain areas) are locked and are accessed by electronic Proximity cards issued to FCDAS employees. These access cards are pre-programmed by the FCDAS Security Manager using computer based security software and are issued to employees after being programmed to reflect that employees need to access areas to perform their work tasks. The security system records Proximity card usage as well as attempted usages.

There is only one way for normal traffic to enter the site. That entryway is guarded by the gate and Guard Shack. Geographically, the station is located in a sparsely populated area 15 miles NNE of Fairbanks.

Security Building – Guard Shack at Site Entrance

7.15 Site Safety

A site safety manager maintains procedures and plans to meet the requirements of NOAA, OSHA, the state of Alaska, and other relevant entities.

First responders are dispatched from the Ft. Wainwright Fire Department (US Army) and the Steese VFD. Fire and ambulance response times are 10-15 minutes. Alaska State Troopers provide the police response. Police response time is highly variable due to the large territory that must be covered by each trooper. The best response time might be 15 – 20 minutes.

7.16 Local Commitment

The Gilmore Creek site has supported various NASA and NOAA programs for over 50 years, and the site is currently under federal land withdrawal until 2029.

8.0 Concluding Remarks

Gilmore Creek has a long history, over 50 years, of supporting various NASA and NOAA programs. There have been VLBI occupations at the site. With the site location and long history, it would be an ideal location to re-establish a VLBI presence and would be an excellent location for SLR to support polar orbiting missions. Effective locations for VLBI2010 and NGSLR still need to be determined and impacts

9.0 Work to be completed

Additional work that needs to be completed for this assessment, include the following:

8. Completion of an RFI Study for broadband.
9. Local hydrology (well levels, aquifer characteristics) and relationship to apparent vertical site stability.
10. Inclusion of a local and regional tie maps.
11. Improved cloud coverage data.
12. A better understanding of the surrounding elevation limits to meet the low elevation requirements for each techniques.
13. Identification of a usable VLBI2010 site either close to the existing compound or within the larger gated area.
14. Identification of a usable NGSLR site that would provide adequate sky coverage in elevation and shielding of the NGSLR LHRS.

10.0 References

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Appendix A: GGOS Site Stability Investigation From MIT

GGOS Site Stability Investigation, Gilmore Creek, Alaska

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3 August 2012

Introduction:
Our principal objective is to investigate the level of stability for potential GGOS sites. GGOS requires site stability of 1 mm in 3-dimensions and long-term stability at the 0.1 mm/yr level. Determining whether specific sites meet GGOS stability requirements will require the most precise techniques available to monitor surface motion and very accurate estimates of short period motions due to tidal, loading, and local hydrologic effects as well as modeling systematic errors that can be difficult to distinguish from surface motions. Strain and tiltmeters (in boreholes or caves) and repeated precise leveling are the most precise ground deformation observation techniques on local scales. Leveling provides information only on vertical motions, is time consuming and is primarily useful for relatively local investigations. It also suffers from systematic errors in areas of high relief that need to be modeled. Strain and tilt meters are susceptible to very local conditions and are primarily useful for detecting short period "events" – determining actual ground deformation from strain measurements is non unique and non trivial. InSAR is not sufficiently precise to determine motions at this level of precision.

GPS offers the opportunity to investigate stability on local, regional, and global scales. GPS has demonstrated measurement precision as good as 0.2 mm horizontal and 1 mm vertical on short baselines and 0.5 mm horizontal and 1.5 mm vertical, and long-term stability at the level of 0.2 mm/yr horizontal and 0.5-1.0 mm/yr vertical on a global scale, in principal close to the precision needed to evaluate site stability at the level required by GGOS. To meet this level of precision requires accurate modeling of a range of factors that influence positioning estimates, including tectonic and magmatic deformation and other real surface movements over short time scales (e.g., tidal loading, hydrology) as well as apparent movements due to measurement errors (e.g., multipath changes, water vapor, monument stability).

Our initial investigation focuses on analysis of the GPS time series.

GPS time series analysis:
We did noise analysis for the GPS station operating at the Observatory (FAIR). Figure 1 shows de-trended time series from the MIT global analysis. FAIR has sufficient data to provide useful results, although clearly effected by large tectonic motions. 1-sigma uncertainties on velocity are of the order 0.1

mm/yr in horizontal and about 0.6 mm/yr for the vertical component. Daily scatter in position (RMS and WRMS) is on the order of 2 – 3.5 mm in horizontal and 10 mm in the vertical. The magnitudes of the annual and semi-annual terms are annotated on the figures and are in the range of 0.5 – 0.9 mm in horizontal and 0.5 – 1 mm in vertical.

These variations reflect un-modeled atmospheric, site [multipath, water table changes, monument stability], tidal [solid, ocean loading], water table variations, and instrument/antenna effects, as well as reference frame instability and tectonic motions. Much more detailed analysis of the GPS time series and other relevant data is necessary to estimate the contribution of these different factors before it will be possible to provide more definitive bounds on site stability.

Tectonics/Geology:

The Gilmore Creek Observatory is located near Fairbanks, Alaska between two major right-lateral, strike-slip fault systems, the Denali Fault to the south and the Kaltag-Tintina fault system to the north. Both of these systems are seismically active and have generated significant (M>7) historic earthquakes. The most recent events were the 2002 Mw=6.7 (foreshock) and Mw=7.9 Denali earthquakes. Substantial seismicity occurs between these major fault systems that is believed to be related to block rotations within the broad shear zone. Complex deformation associated with fault interactions and strain accumulation/release within the region is likely, as well as continuing postseimic motions from the 2002 Denali Earthquakes.

No active volcanoes are reported in Central Alaska. Elastic response to mountain glacier retreat is likely to effect vertical motions at this site. In addition, postglacial rebound could reach a few mm/yr in the region of the Observatory. These will need to be monitored to meet GGOS stability goals.

Atmospheric:

Approximately 30 cm of rainfall and 1.7 meters of snowfall occur at the location of the Observatory annually. Elastic loading due to rain and snow could produce vertical motions at the site. These will need to be monitored to assure vertical stability at the 1 mm level.

Local hydrology: Needs further study of aquifers and water utilization.

Conclusions/Recommendation for the Gilmore Creek Observatory GGOS site:

Gilmore Creek Observatory is located in a tectonically active area of central Alaska (Figure 2). Although the site has small uncertainties on horizontal velocities (0.1 mm/yr), it is influenced by elastic strain accumulation associated with the NA-Pacific plate subduction boundary, active strike-slip fault systems in the “back-arc”, and postseismic motions from the Denali earthquakes. Large vertical motions due to postglacial isostatic adjustment (few mm/yr), and elastic loading associated with glacial retreat and annual snow and rainfall are likely. This location will require detailed monitoring and modeling of tectonic, isostatic, and elastic motions in order to meet GGOS stability requirements.

To Do:

Local hydrology (well levels, aquifer characteristics) and relationship to apparent vertical site stability. Network analysis of multiple stations (i.e., differencing station positions may help separate site stability from instrumental/wave propagation effects). We are not aware of any evidence for landslide activity, but this should be checked in more detail.

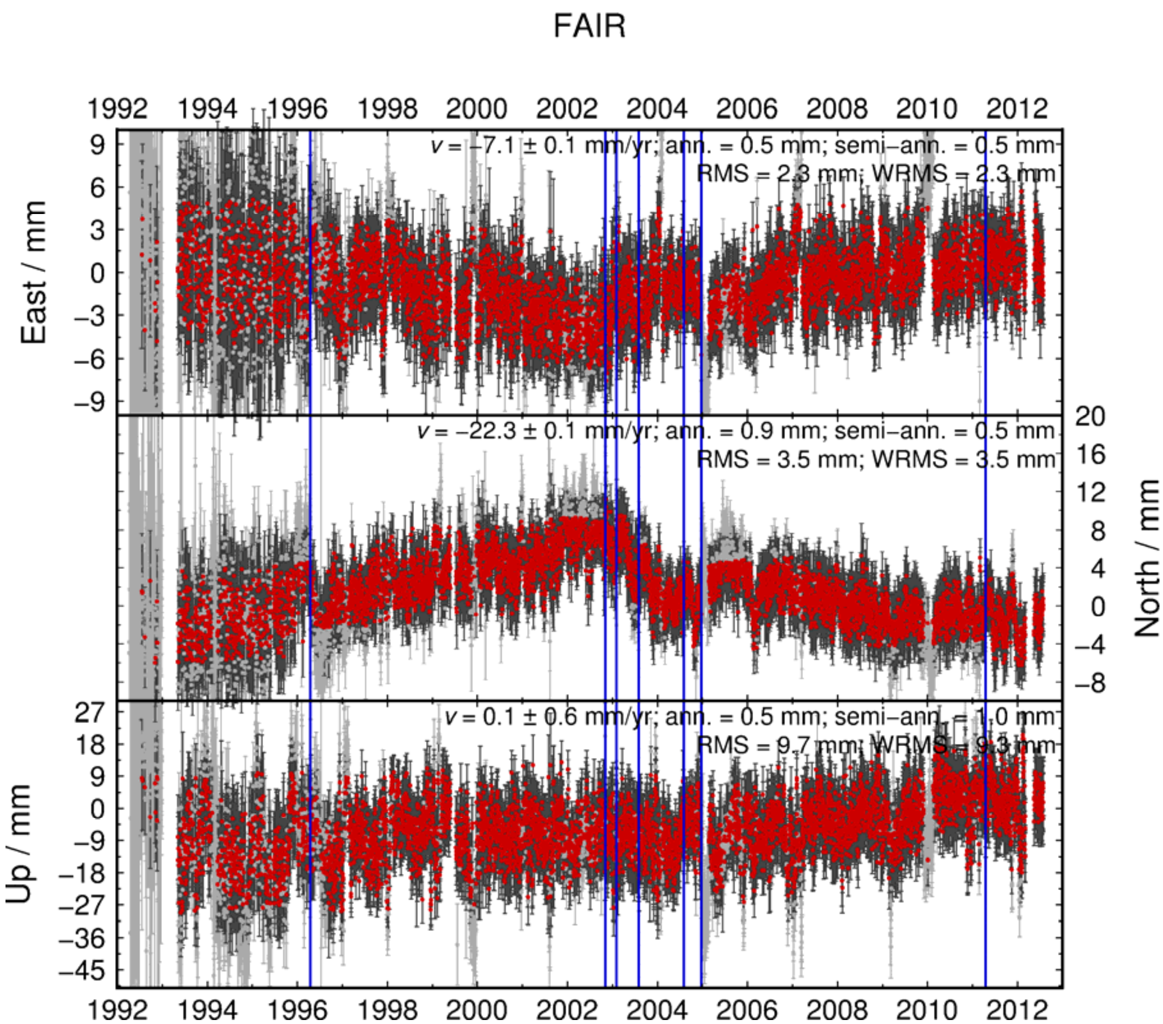

Figure 1. Gilmore Creek (FAIR) GPS time series and statistics.

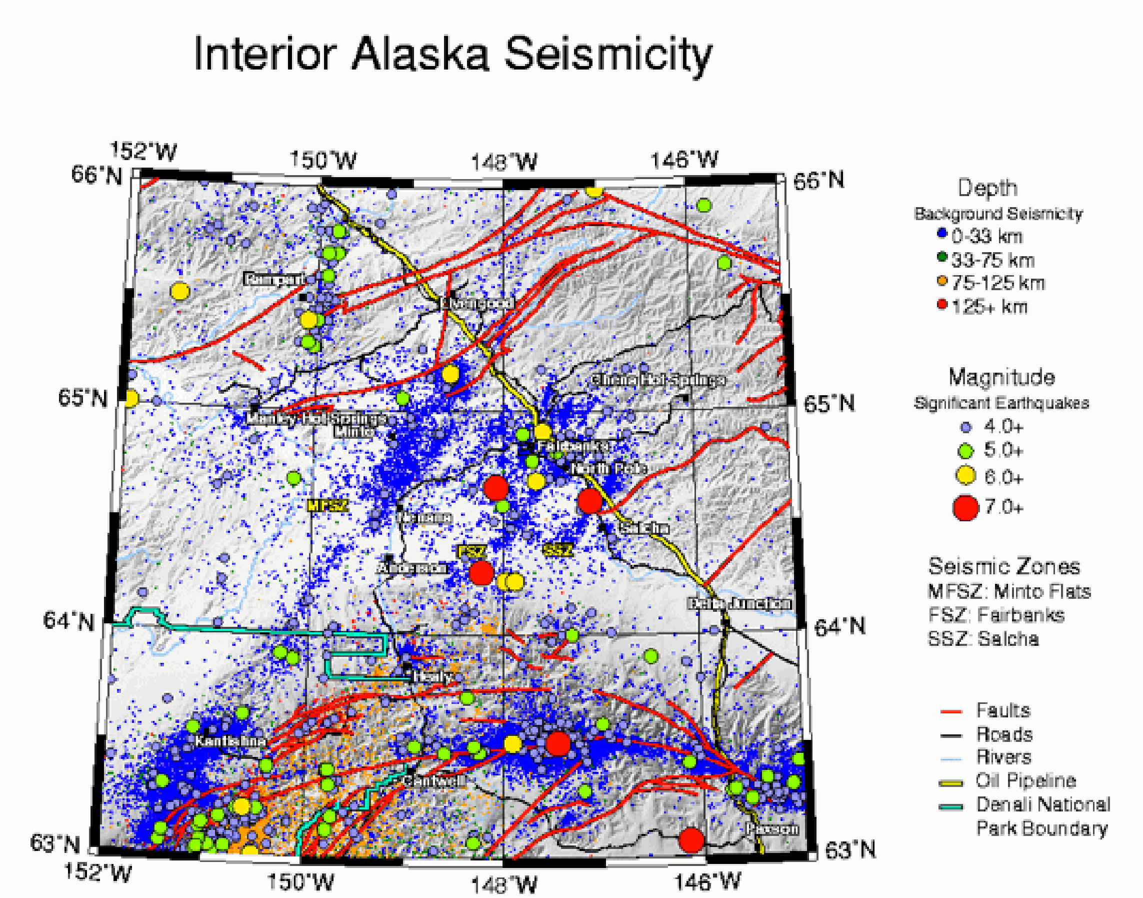

Figure 2. Seismicity from the Alaska Earthquake Information Center (AEIC) (http://www.aeic.alaska.edu/maps/interior_seismicity_map.html). The Gilmore Creek Observatory is located approximately 22 km NE of Fairbanks (~147.5°E; ~65°N).

Appendix B: List of Acronyms

CORS	Continuously Operating Reference Station
DOMES	Directory of MERIT Sites
DORIS	Doppler Orbitography and Radiopositioning Integrated by Satellite
FAA	Federal Aviation Administration
FCDAS	Fairbanks Command, Data, and Acquisition Station
GCGO	Gilmore Creek Geophysical Observatory
GGAO	Goddard Geophysical and Astronomical Observatory
GGOS	Global Geodetic Observing System
GNSS	Global Navigation Satellite System
GPS	Global Positioning Satellite
HPWREN	High Performance Wireless Research and Education Network
HTSI	Honeywell Technology Solutions Inc.
IAG	International Association of Geodesy
IDS	International DORIS Service
IfA	Institute for Astronomy
IGS	International GNSS Service
ILRS	International Laser Ranging Service
IVS	International VLBI Service for Geodesy and Astrometry
JSC	Joint Spectrum Center
LAGEOS	Laser Geodynamic Satellite
MIT	Massachusetts Institute of Technology
MOBLAS	MOBile Laser System
NASA	National Aeronautics and Space Administration
NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanic and Atmospheric Administration
RFI	Radio Frequency Interference
SGP	Space Geodesy Project
SLR	Satellite Laser Ranging
VLBI	Very Long Baseline Interferometry