UNAVCO GEODETIC DATA SYSTEMS
NGNLA WORKSHOP
MAY, 2015

Fran Boler, Chuck Meertens, Dave Phillips, and Christine Puskas
and many others in the IT, Data Archive, and Data Management Teams at UNAVCO

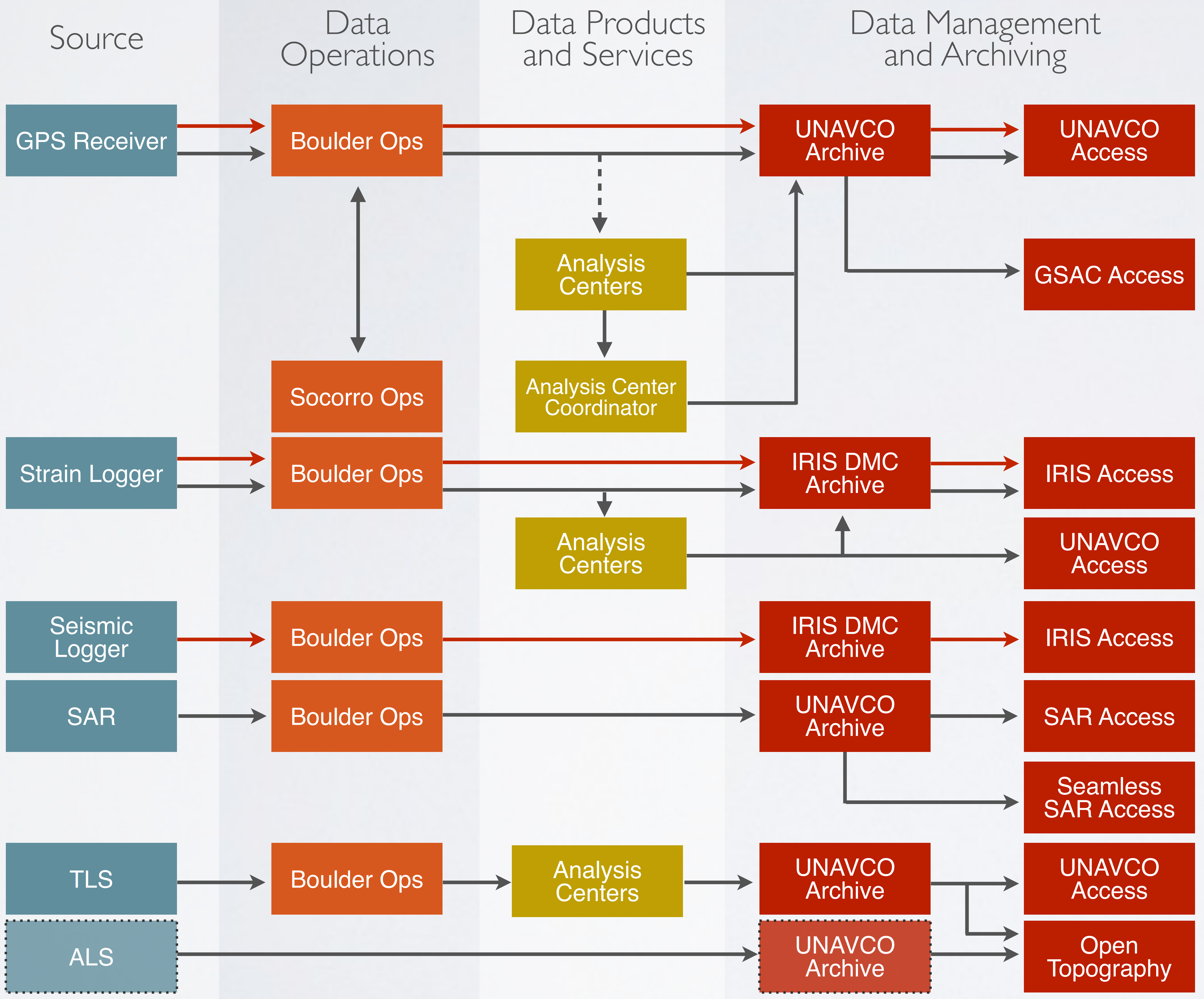
OUTLINE

*UNAVCO Geodetic Data Infrastructure
Open data
Data Management
IT
Future directions and drivers

*Cyberinfrastructure
Web services APIs
GSAC
RESTful services
Collaboration across domains, institutions, and borders
Future directions and drivers

*Data Quality
Metadata management
Techniques for QC and QA
Stations health and data quality
Future directions and drivers

UNAVCO GEODETIC DATA: SOURCES TO USERS



Data: Sources to Users

- Manage or Access Sources
- Data Operations
- Data Products and Services
- Data Management and Archiving
- Cyberinfrastructure

UNAVCO

OPEN DATA POLICY

UNAVCO GPS Data Policy

Archiving of data

All UNAVCO-facilitated GPS and other GNSS data and metadata must be archived at UNAVCO upon collection. Data providers are responsible for providing attribution information with submitted data, including sponsor and provider contact information.

Accessibility

Metadata will be made publicly available when placed in the archive. Data will be made publicly available when placed in the archive, unless an investigator has documented a period of exclusive us that is specified by the sponsor, typically in the award letter.

Attribution

By accessing data from the UNAVCO archive, users agree to appropriate attribution to providers and their sponsors, acknowledgment of UNAVCO and its sponsors, and to adherence to professional and ethical standards.

UNAVCO

DIGITAL OBJECT IDENTIFIERS FOR DATA

Attribution Using Data Set Digital Object Identifiers

UNAVCO is publishing DOIs for data sets (campaign and station).

home › data › doi

Data Set Digital Object Identifier Search

Mammoth DOI Search

Found 5 Results

Mammoth/Mojave 1994: Mammoth
Citation: Miller, M. Meghan, Golombek, Matthew P., Dokka, Roy K., 1997, Mammoth/Mojave 1994: Mammoth, UNAVCO, GPS Data Set, doi:10.7283/T5D798B5

Mammoth/Mojave 1994: Combined Sites
Citation: Miller, M. Meghan, Golombek, Matthew P., Dokka, Roy K., 1997, Mammoth/Mojave 1994: Combined Sites, UNAVCO, GPS Data Set, doi:10.7283/T5RF5RZP

Mammoth/Mojave 1994: Mojave
Citation: Miller, M. Meghan, Golombek, Matthew P., Dokka, Roy K., 1997, Mammoth/Mojave 1994: Mojave, UNAVCO, GPS Data Set, doi:10.7283/T5MS3QNP

Mammoth 1995
Citation: Miller, M. Meghan, Humphreys, Eugene, Dokka, Roy K., Webb, Frank H., 1995, Mammoth 1995, UNAVCO, GPS Data Set, doi:10.7283/T5C8276B

Mammoth/Mojave 1994
Aggregation of Multiple Data Sets
Citation: Miller, M. Meghan, Golombek, Matthew P., Dokka, Roy K., 1997, Mammoth/Mojave 1994, UNAVCO, GPS Data Set, doi:10.7283/T57H1GGM

home › data › doi › doi:10.7283

GPS Data Set Citation Summary

Identifier:	10.7283/T5W66HPD
Title:	Mojave 1997
Authors:	M. Meghan Miller, Eugene Humphreys, Roy K. Dokka and Frank H. Webb
Published:	2001
Publisher:	UNAVCO, Inc.
Description:	Campaign
Date Range:	1997-06-23 through 1997-07-19
Citation:	Miller, M. Meghan , Humphreys, Eugene , Dokka, Roy K. and Webb, Frank H., 2001, Mojave 1997, UNAVCO, GPS Data Set, doi:10.7283/T5W66HPD
Related Publications:	Timothy Dixon, Fred Farina, Charles DeMets, Francisco Suarez Vidal, John Fletcher, Meghan Miller, Osvaldo Sanchez, Bertha Marquez-Azua, Paul Umhoefer, New Kinematic Models for Pacific-North America Motion from 3 Ma to Present: Evidence for a "Baja California shear zone". Geophysical Research Letters. v.27, p. 3961-3964, doi:10.1029/1999GL900405, 2000. M. Meghan Miller, Daniel J. Johnson, Timothy H. Dixon, and Roy K. Dokka, 2001, Refined kinematics of the Eastern California shear zone from GPS observations, 1993-1998. Journal of Geophysical Research. v. 106, p. 2245-2264, doi:10.1029/2000JB900328. S. C. McClusky, S. C. Bjornstad, B. H. Hager, R. W. King, B. J. Meade, M. M. Miller, F. C. Monastero and B. J. Souter, 2002, Present day kinematics of the Eastern California Shear Zone from a geodetically constrained block model. Geophysical Research Letters, v. 28, p. 3369-3372, doi:10.1029/2001GL013091. Kenneth E. Austin and M. Meghan Miller, 2002, The co-seismic displacement fields for the 1992 Landers and 1999 Hector Mine earthquakes in California, from regional GPS observations. The Hector Mine, California, earthquake of 16 October 1999, Bulletin of the Seismological Society of America, v. 92, p. 1365-1376, doi:10.1785/0120000931.
Data Availability:	Available by request
Data Access:	http://www.unavco.org/data/gps-gnss/data-access-methods/dai2/dai2.html#scope=Campaign;groupingMod=Equals;grouping=Mojave 1997;dataStartDate=1997 Jun 23;dataEndDate=1997 Jul 19;
See Also:	UNAVCO Data Policy UNAVCO Attribution Policy Background information, DOI for Data at UNAVCO

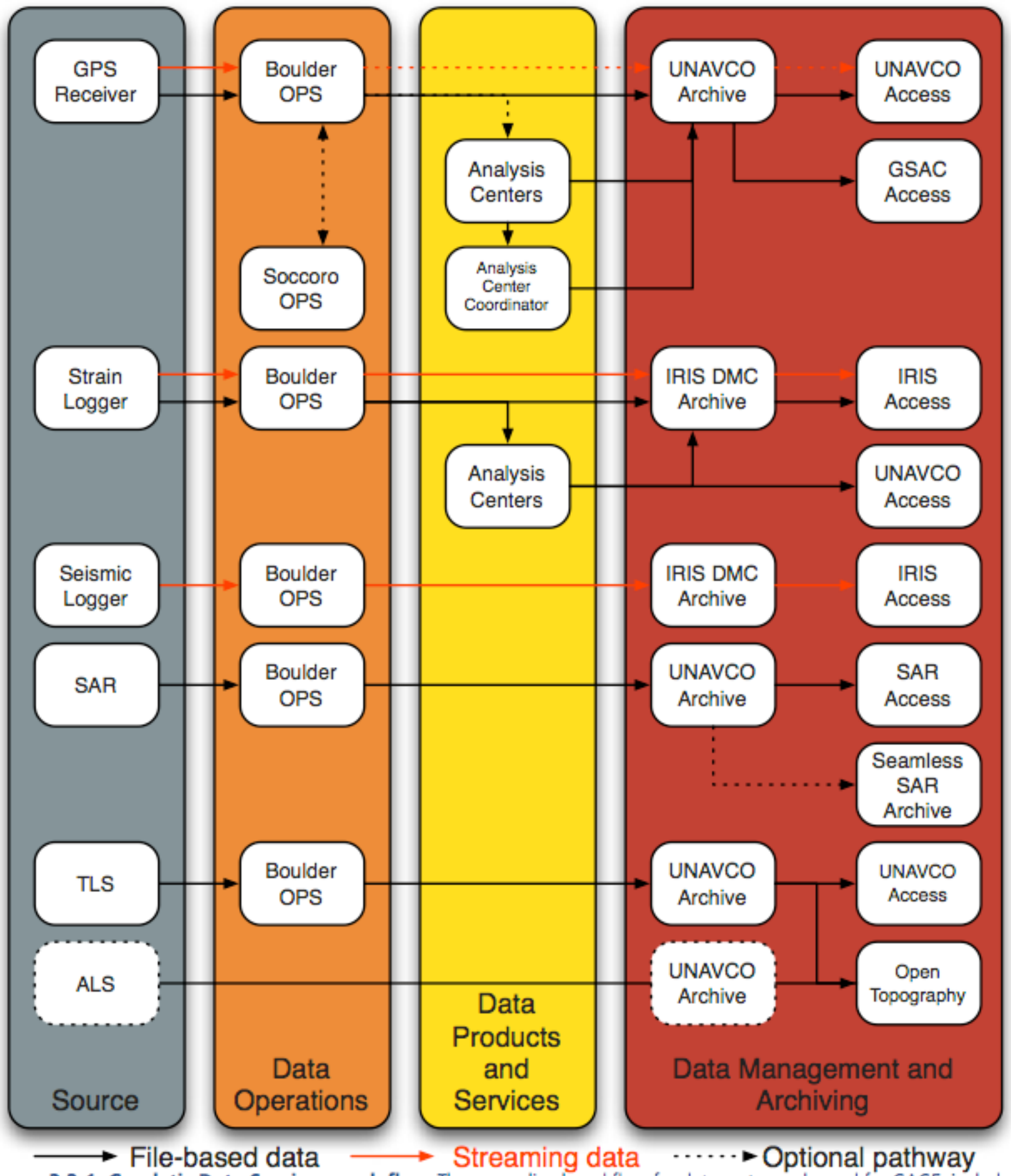


Figure 3.2-1. Geodetic Data Services work flow. The generalized workflow for data systems planned for GAGE, includes roles of subawardees and partners. The GAGE Facility will develop internal consistency and integration of data work flow to maintain and enhance its core services, to develop a new data system for TLS, to provide improved access to community data held at the facility for data users and external partners, and to develop mechanisms to acquire, track, manage and disseminate products and related provenance metadata that will enable the broadest possible use. Cyberinfrastructure developments enhance capabilities for data handling, distribution and visualization both within and external to GAGE.

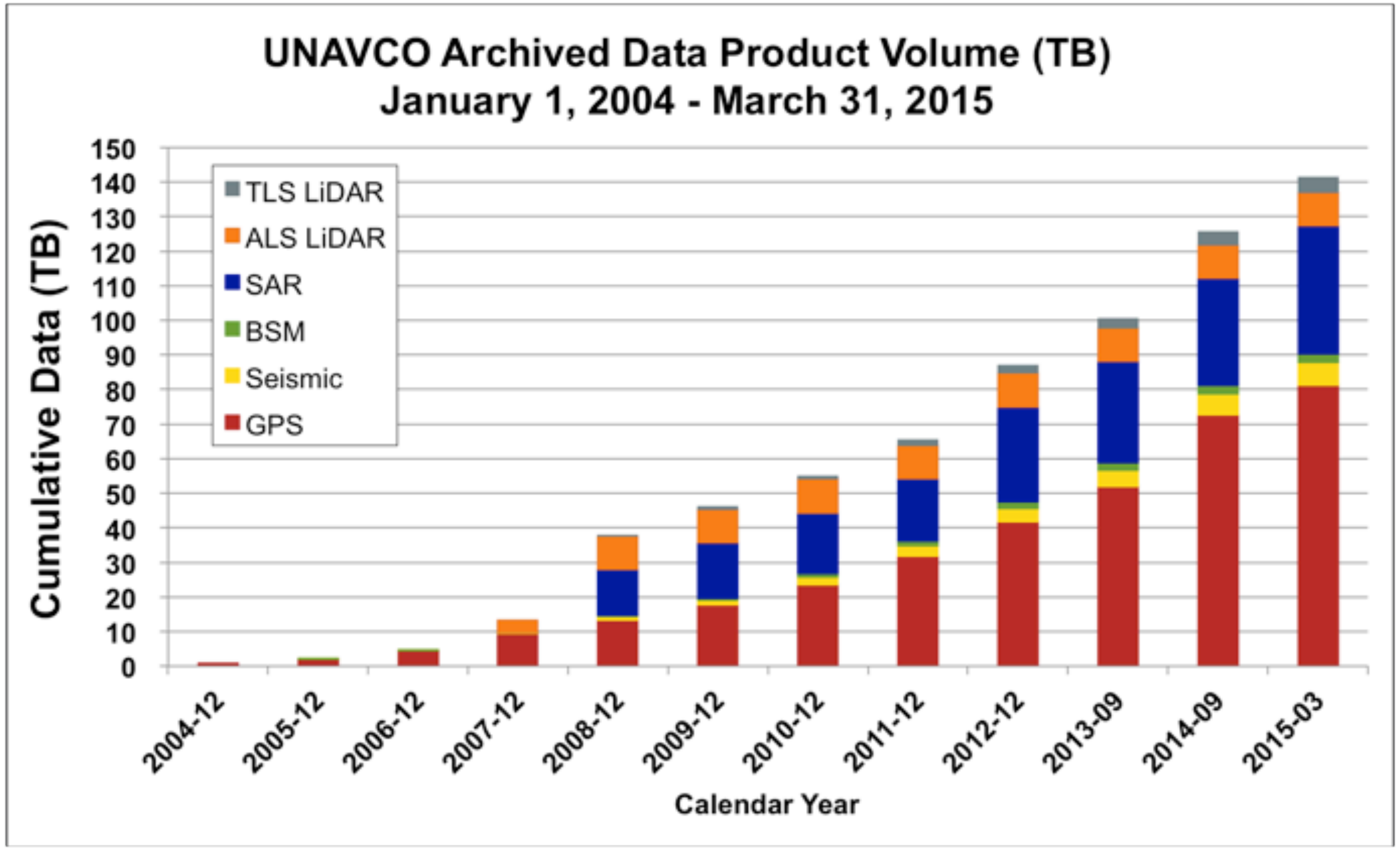
Table 3.2-1. Geodetic Data Prodcuts for GAGE.

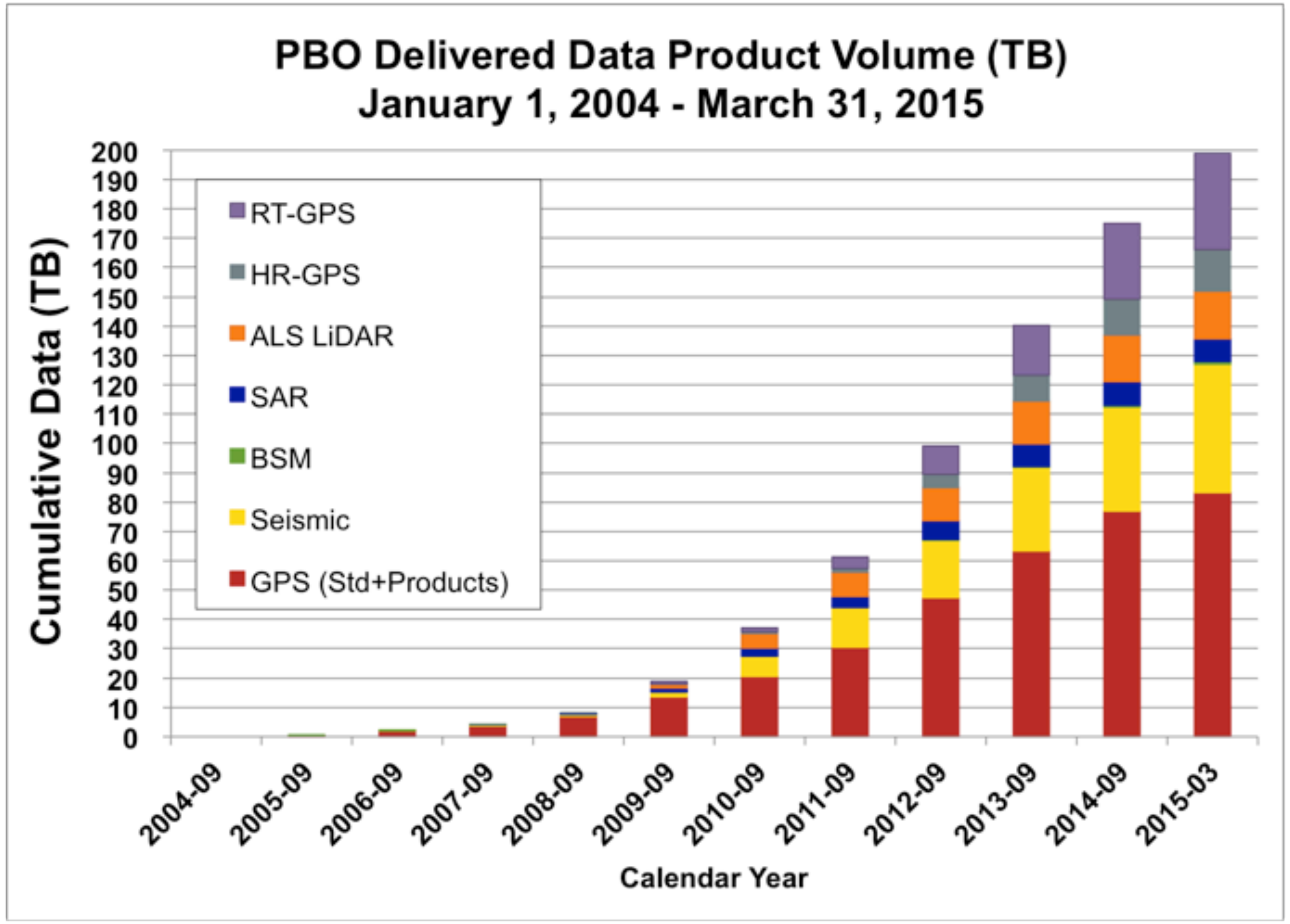
INSTRUMENT	LEVEL	PRODUCT	FORMAT	PRODUCT GENERATION FREQUENCY	PRODUCER/ DISTRIBUTOR
Global Positioning System (GPS) Receiver	0	Standard-Rate (15-sec) raw data	T00	Hourly, sub-daily or daily	UNAVCO/ UNAVCO
		High-Rate (1-sps, 5-sps) raw data	T00	Hourly (upon request)	UNAVCO/ UNAVCO
		Real-Time raw data	BINEX, RTCM	Real-time	UNAVCO/ UNAVCO
		Community continuous raw data	Varies	Hourly, sub-daily or daily	Community PI's/UNAVCO
		Survey-mode raw data	Varies	Varies	UNAVCO, Community PI's/UNAVCO
		Metadata	Database	Varies	UNAVCO
	1	Standard-Rate quality checked data	RINEX	Daily	UNAVCO/UNAVCO
		High-Rate quality checked data	RINEX	Varies	UNAVCO/UNAVCO
		Real-Time quality checked data	RINEX	Daily, varies	UNAVCO/UNAVCO
		Community continuous quality checked data	RINEX	Daily, varies	UNAVCO/UNAVCO
		Survey-mode (campaign) quality checked data	RINEX	Daily, varies	UNAVCO/UNAVCO
	2	Station position solutions	SINEX	Daily, 15-days, 3-months	MIT*, CWU*, NMT*/UNAVCO
		Station position time series	ASCII	Daily, 15-days, 3-months	MIT*, CWU*, NMT*/UNAVCO
		Station position velocity estimates	ASCII	Varies	MIT*, CWU*, NMT*/UNAVCO
		Station position offsets for significant events (e.g. coseismic)	ASCII	Varies	MIT*, CWU*, NMT*/UNAVCO
		Station position quality assurance parameters	ASCII	Varies	UNR (Blewitt)/UNAVCO
		Tropospheric Delay Parameters	ASCH	Daily	MIT*, CWU*, NMT*/UNAVCO
Borehole Strainmeter (BSM)	0	20-sps, 1-sps, 10-min raw strain series	Bottle, SEED	Hourly, daily	UNAVCO/DMC*, NCEDC*
		30 min, 1 hour instrument health series	Bottle, SEED	Hourly, daily	UNAVCO/DMC*, NCEDC*
		1-sps, 30-min environmental series	Bottle, SEED	Hourly, daily	UNAVCO/DMC*, NCEDC*
		Borehole geophysical logs, samples	Varies	During installation	UNAVCO/UNAVCO
		Station metadata	Database	Varies	UNAVCO
	2	2a Corrected and scaled strain and environmental series	XML, ASCII	Daily, bi-weekly	UNAVCO/DMC*, NCEDC*, UNAVCO
		2b Corrected and scaled strain and environmental series	XML, ASCII	4-months	UNAVCO/DMC*, NCEDC*, UNAVCO
		Station notebooks	PDF	Varies	UNAVCO
Laser Strainmeter (LSM)	0	1-sps raw strain, instrument health, and environmental series	Ice-9, SEED	Daily	UCSD*/DMC*, NCEDC*
		Station metadata	Database	Varies	Subawardee (UCSD)
	2	Corrected and scaled strain and environmental series	XML, ASCII	Bi-weekly, 4-months	UCSD*/DMC*, NCEDC*, UNAVCO
		Station notebooks	ASCII	Varies	Subawardee (UCSD)
Borehole Seismometer	0	100-sps raw data	SEED	Streaming	UNAVCO/DMC*
		200-sps raw data	SEED	Streaming (some stations)	UNAVCO/DMC*
		Seismic Metadata	DATALESS SEED	Varies	UNAVCO
Pore Pressure Meter	0	1 sps raw	SEED, ASCII	Streaming, Daily	UNAVCO/DMC*, UNAVCO
Tiltmeter	0	1-sps raw	ASCII	Streaming	UNAVCO/UNAVCO
	0	1-min raw	ASCII	Daily	UNAVCO/UNAVCO
Terrestrial Laser Scanning (TLS)	0	Scanner data (raw, proprietary format)	Varies	Varies	UNAVCO/UNAVCO
	2	Point cloud data (merged, aligned, georeferenced, unfiltered)	ASCII, LAS, other	Varies	UNAVCO/UNAVCO
Airborne Laser Scanning (ALS)	3	Point cloud data (unfiltered, filtered)	ASCII, LAS, other	Static	NCALM/OpenTopography
	3	Digital elevation model (unfiltered, filtered)	Varies	Static	NCALM/OpenTopography
	3	Hillshade image (unfiltered, filtered)	GeoTIFF	Static	NCALM/OpenTopography
Satellite Synthetic Aperture Radar (SAR)	0	Raw SAR sensor data	CEOS, ENV1	Varies (orbit dependent)	ESA, NASA (ASF)/UNAVCO**
	1	Slant range single look complex (SSC) data	COSAR	Varies (orbit dependent)	DLR/UNAVCO**
Meteorlogic Sensor	0	Temperature, humidty, barometric pressure, other	T00	Hourly/Daily	UNAVCO/UNAVCO
	1	Temperature, humidty, barometric pressure, other	RINEX	Hourly/Daily	UNAVCO/UNAVCO
	2	Soil mosture, snow depth, snow-water equivalent, NLDAS, SNOTEL, vegetation index, precipitation***	ASCII	Hourly/Daily	Community PI (Larson)/UNAVCO
	2	Time series, maps, animations	Varies	Hourly/Daily	Community PI (Larson)/UNAVCO

* Supported by UNAVCO subaward. ** UNAVCO re-distributes data to authorized users.
*** Data products are generated from combination of GPS observations (multipath), meteorologic observations, direct soil and vegetation measurements, etc.

UNAVCO

VOLUMES ARCHIVED & DISTRIBUTED





Data management functions are the same independent of volumes.

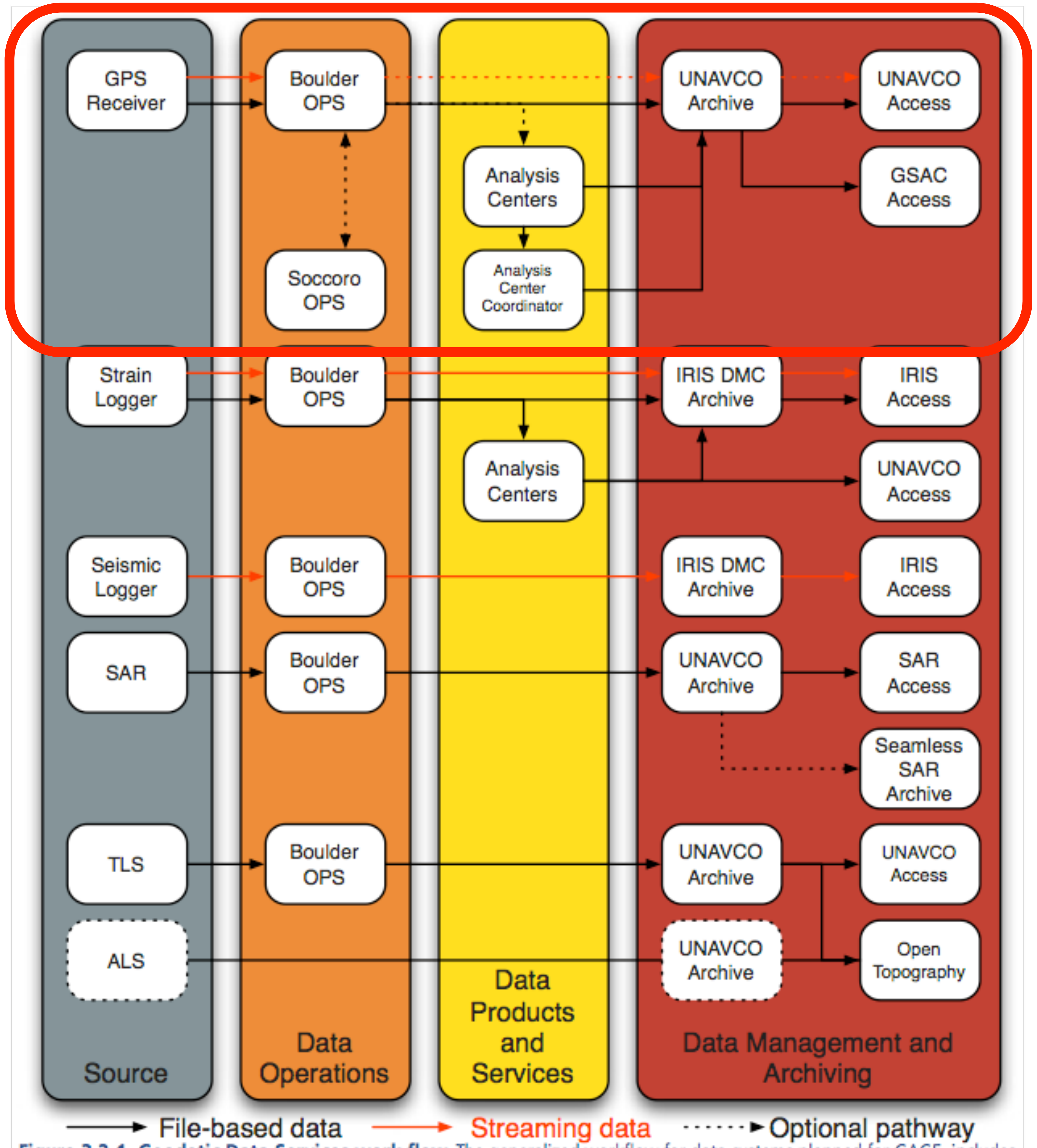


Figure 3.2-1. Geodetic Data Services work flow. The generalized workflow for data systems planned for GAGE, includes roles of subawardees and partners. The GAGE Facility will develop internal consistency and integration of data work flow to maintain and enhance its core services, to develop a new data system for TLS, to provide improved access to community data held at the facility for data users and external partners, and to develop mechanisms to acquire, track, manage and disseminate products and related provenance metadata that will enable the broadest possible use. Cyberinfrastructure developments enhance capabilities for data handling, distribution and visualization both within and external to GAGE.

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		200-sps raw data	SEED	Streaming (some stations)	UNAVCO/DMC*
		Seismic Metadata	DATALESS SEED	Varies	UNAVCO
Pore Pressure Meter	0	1 sps raw	SEED, ASCII	Streaming, Daily	UNAVCO/DMC*, UNAVCO
Tiltmeter	0	1-sps raw	ASCII	Streaming	UNAVCO/UNAVCO
	0	1-min raw	ASCII	Daily	UNAVCO/UNAVCO
Terrestrial Laser Scanning (TLS)	0	Scanner data (raw, proprietary format)	Varies	Varies	UNAVCO/UNAVCO
	2	Point cloud data (merged, aligned, georeferenced, unfiltered)	ASCII, LAS, other	Varies	UNAVCO/UNAVCO
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Satellite Synthetic Aperture Radar (SAR)	0	Raw SAR sensor data	CEOS, ENV1	Varies (orbit dependent)	ESA, NASA (ASF)/UNAVCO**
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Meteorlogic Sensor	0	Temperature, humidty, barometric pressure, other	T00	Hourly/Daily	UNAVCO/UNAVCO
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	2	Soil mosture, snow depth, snow-water equivalent, NLDAS, SNOTEL, vegetation index, precipitation***	ASCII	Hourly/Daily	Community PI (Larson)/UNAVCO
	2	Time series, maps, animations	Varies	Hourly/Daily	Community PI (Larson)/UNAVCO

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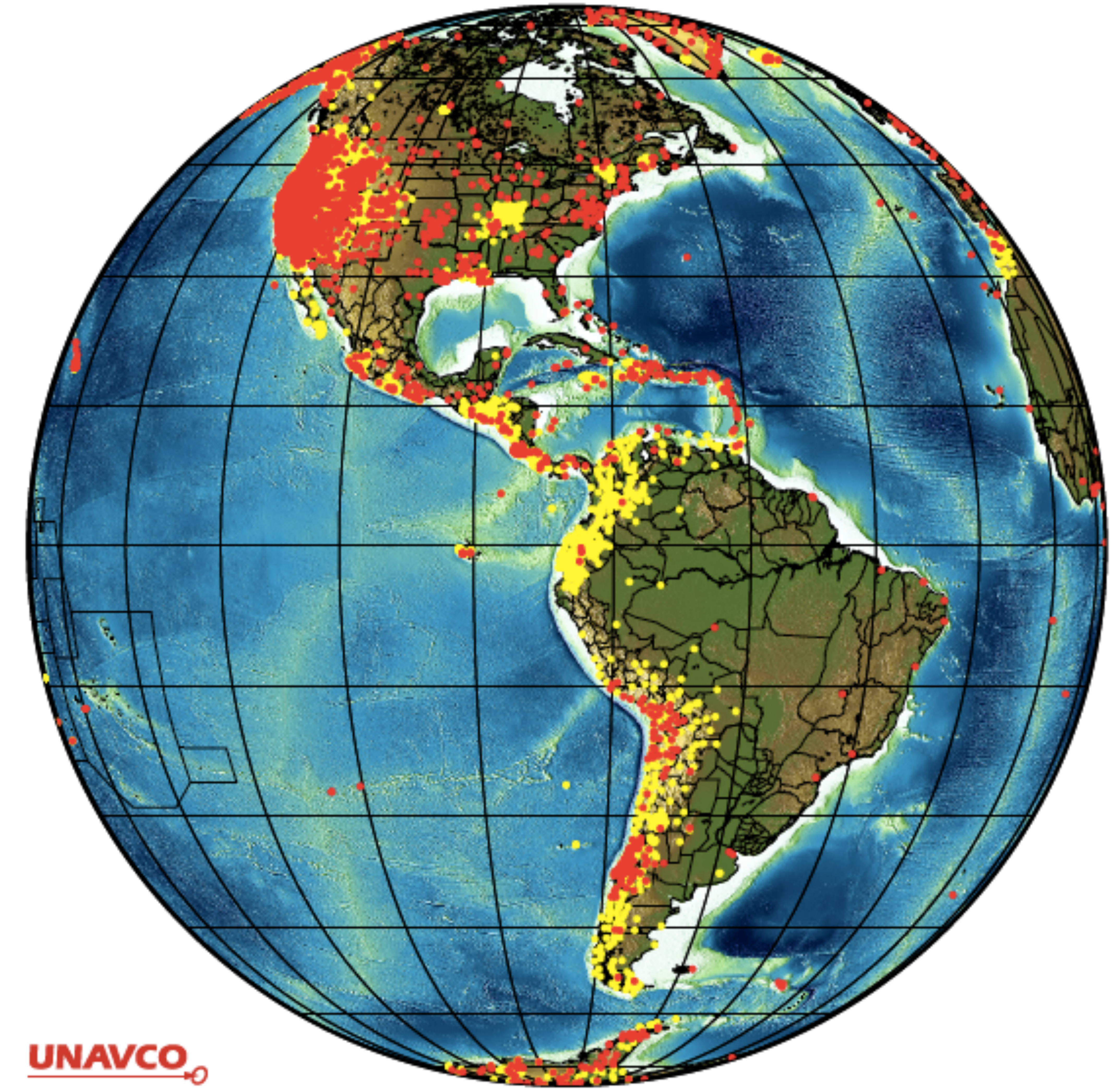
W. HEMISPHERE GPS DATA ARCHIVED

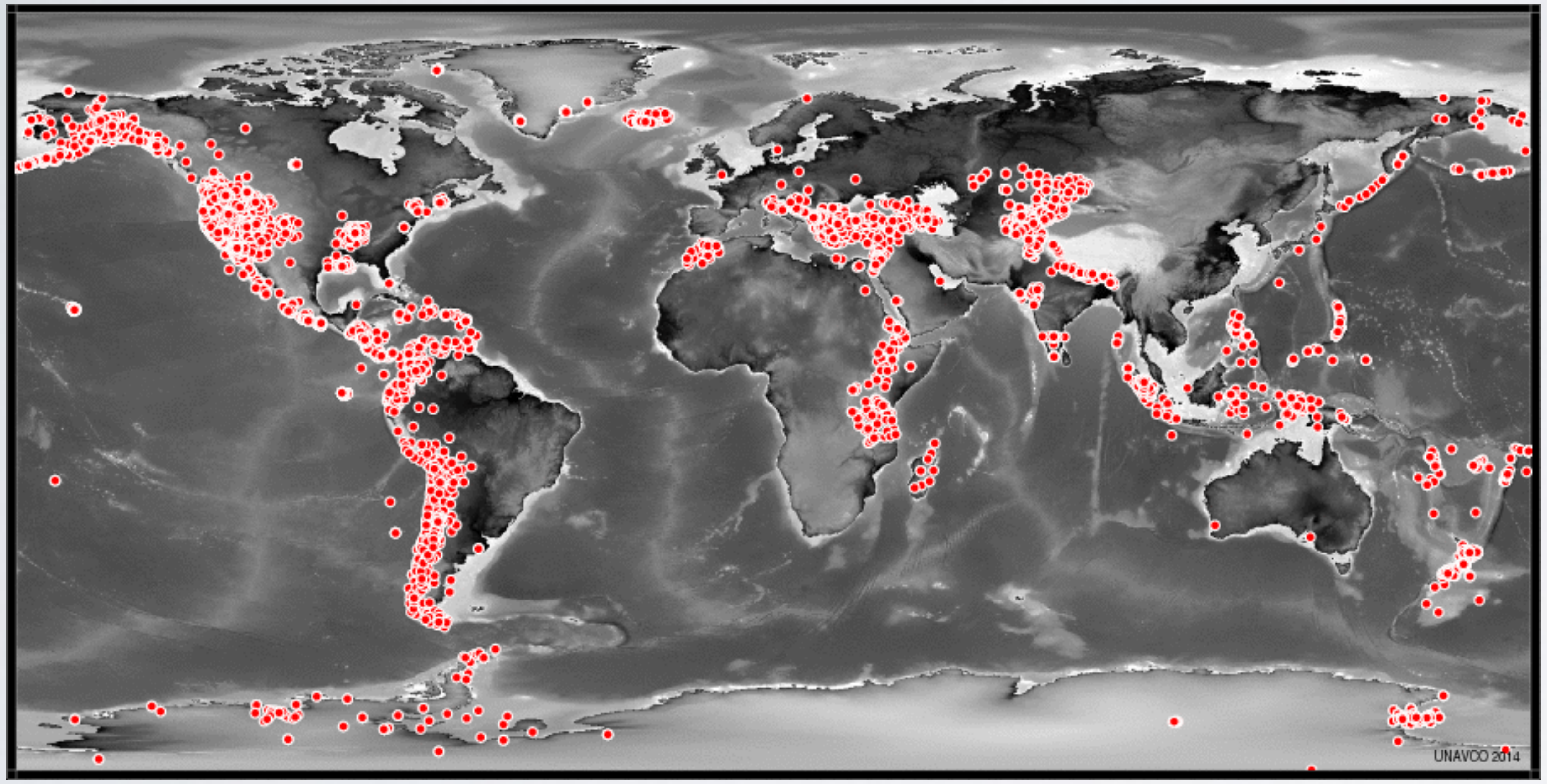
Campaign GPS (yellow)

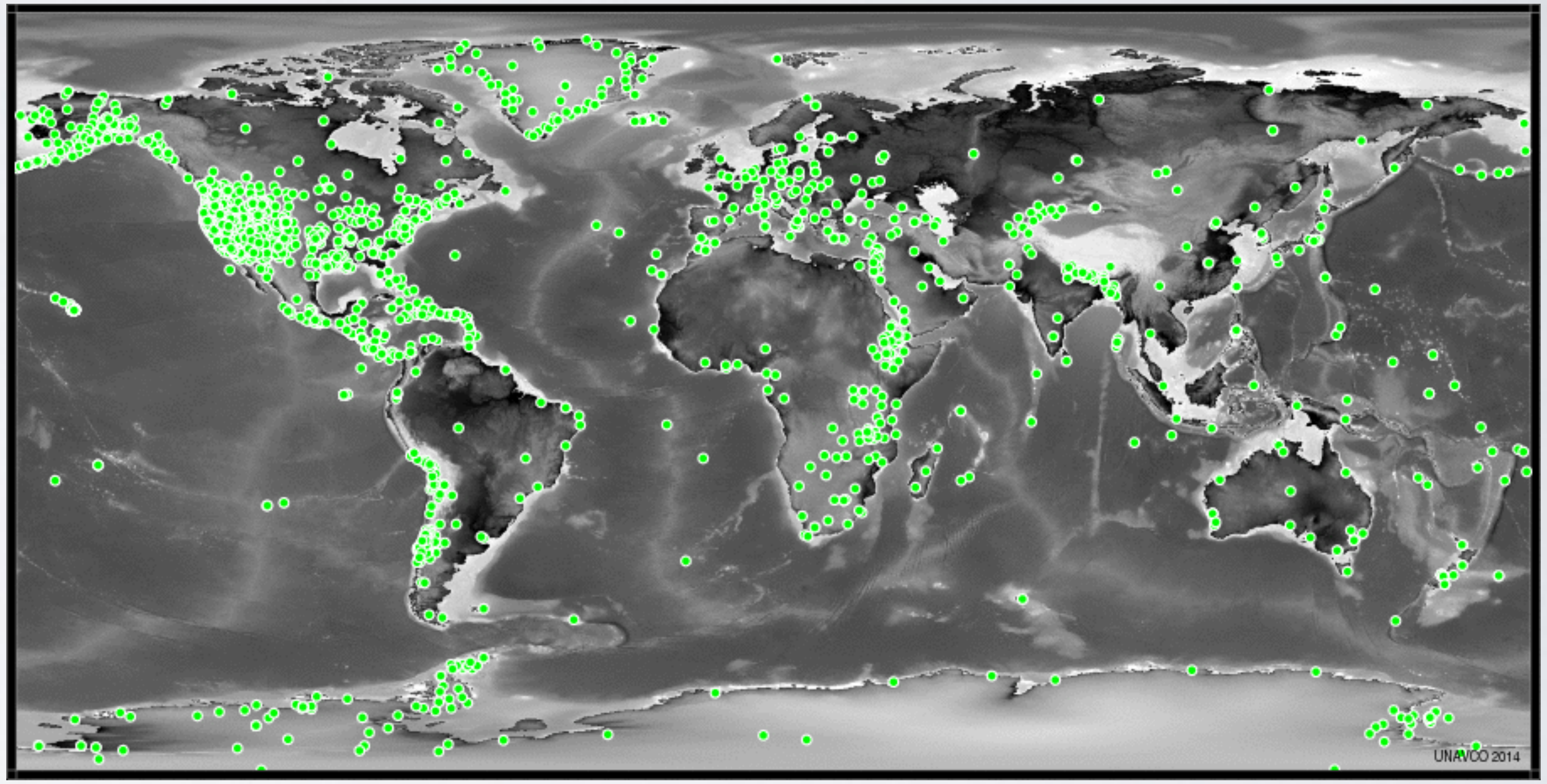
Continuous GPS (red)



Produced by UNAVCO/Mencin 2015

GLOBAL GPS DATA ARCHIVED



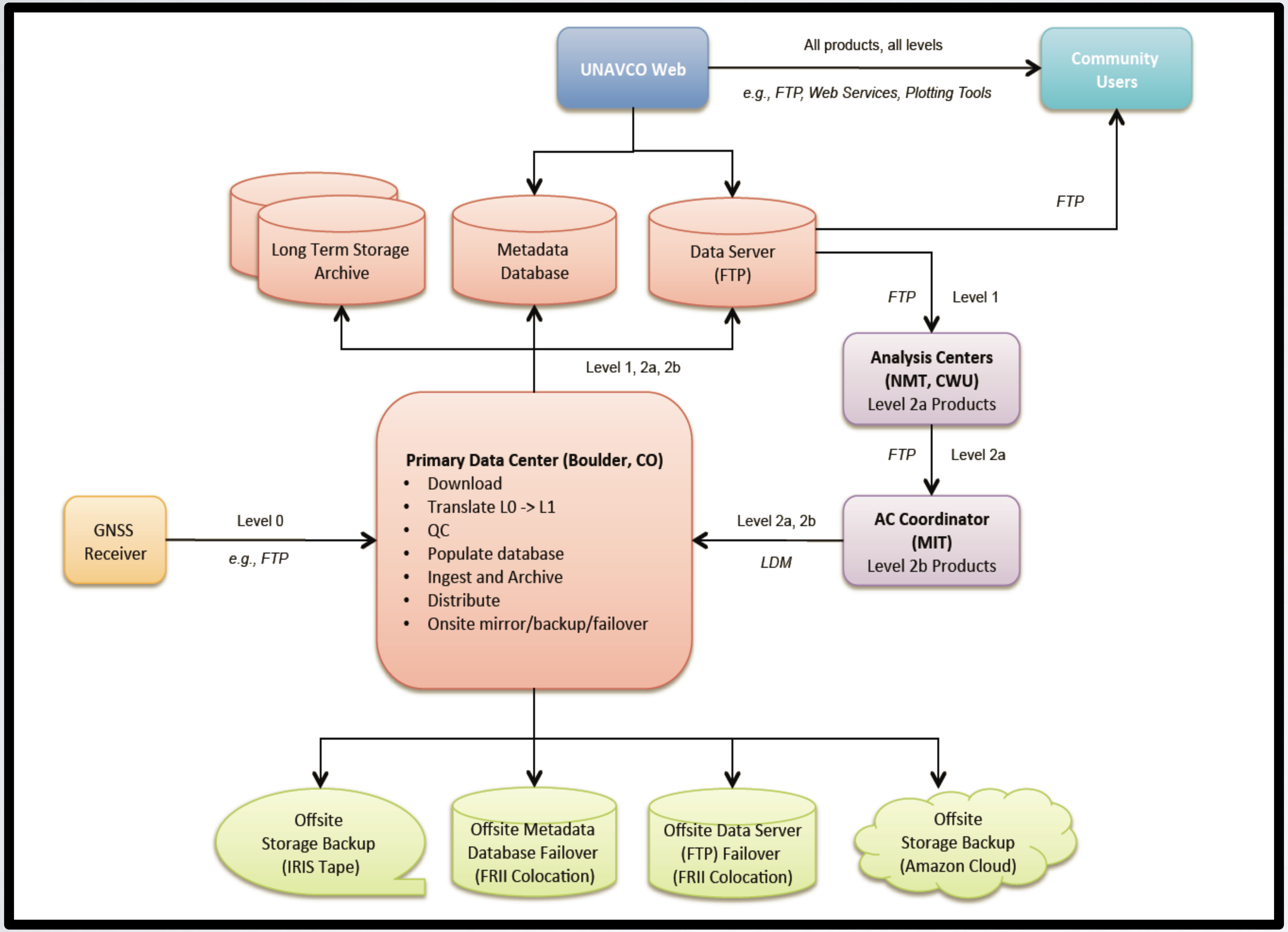


Campaign GPS

Continuous GPS

Collaboration/cooperation with US and international researchers

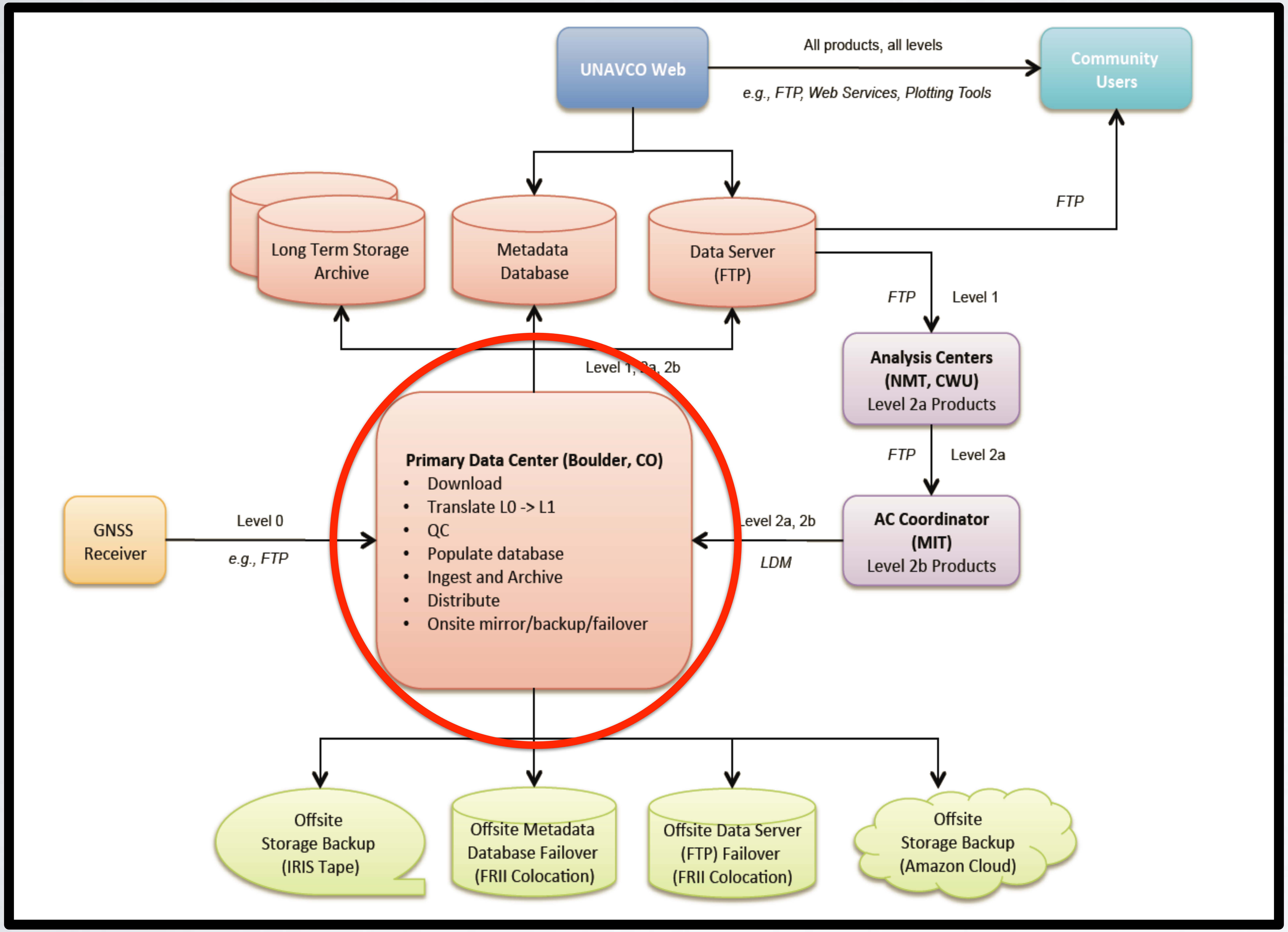
DATA MANAGEMENT FOR GPS/GNSS



<u>Functions</u>

- Accept Incoming Data
- Format, Extract Metadata, QC
- Associated Metadata Tracking
- Archiving for Long-term Preservation
- Data Products and Services
- Distribution
- Cyberinfrastructure

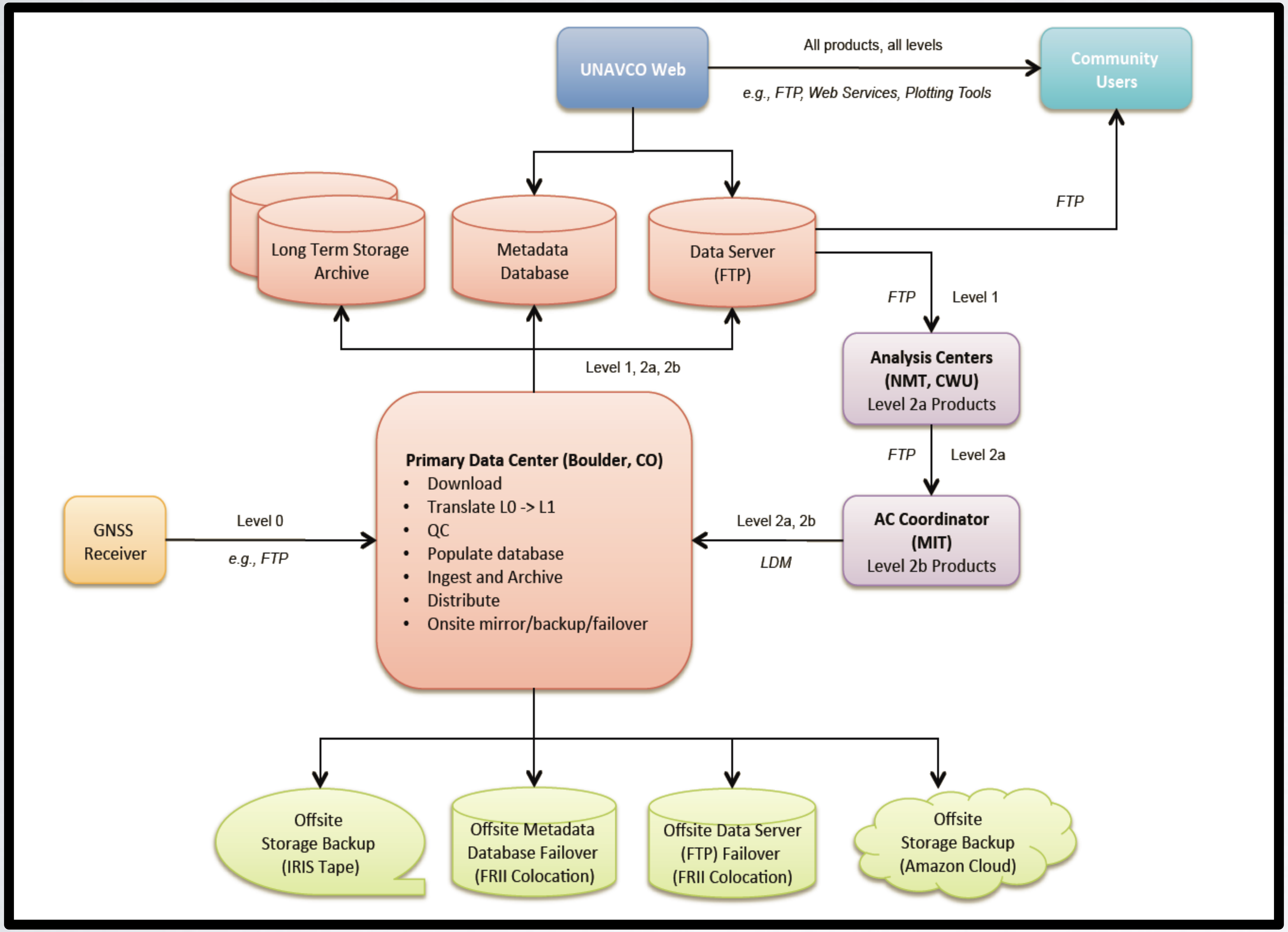
DATA MANAGEMENT FOR GPS/GNSS



Scale

- 2,700 Active Stations
- Delivery intervals: Sub-hourly, Hourly, Sub-daily, Daily, Intermittent
- Streams
- Data rates (sec): 0.1, 0.2, 1, 2, 5, 10, 15, 30
- ~20,000 incoming files per day
- ~10^6 operations per day (e.g. compress, cp, db request, filter)

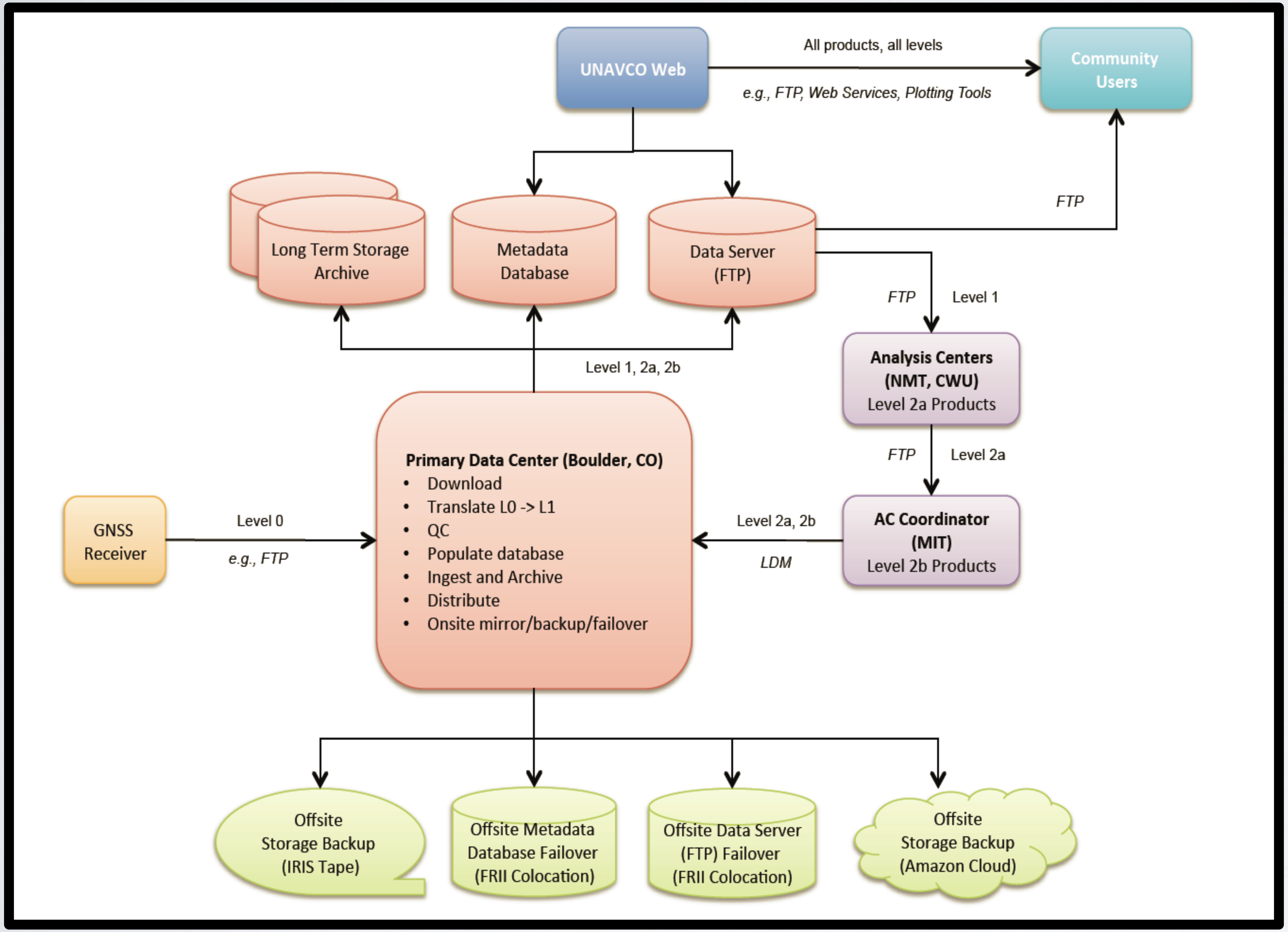
DATA MANAGEMENT FOR GPS/GNSS



IT Infrastructure

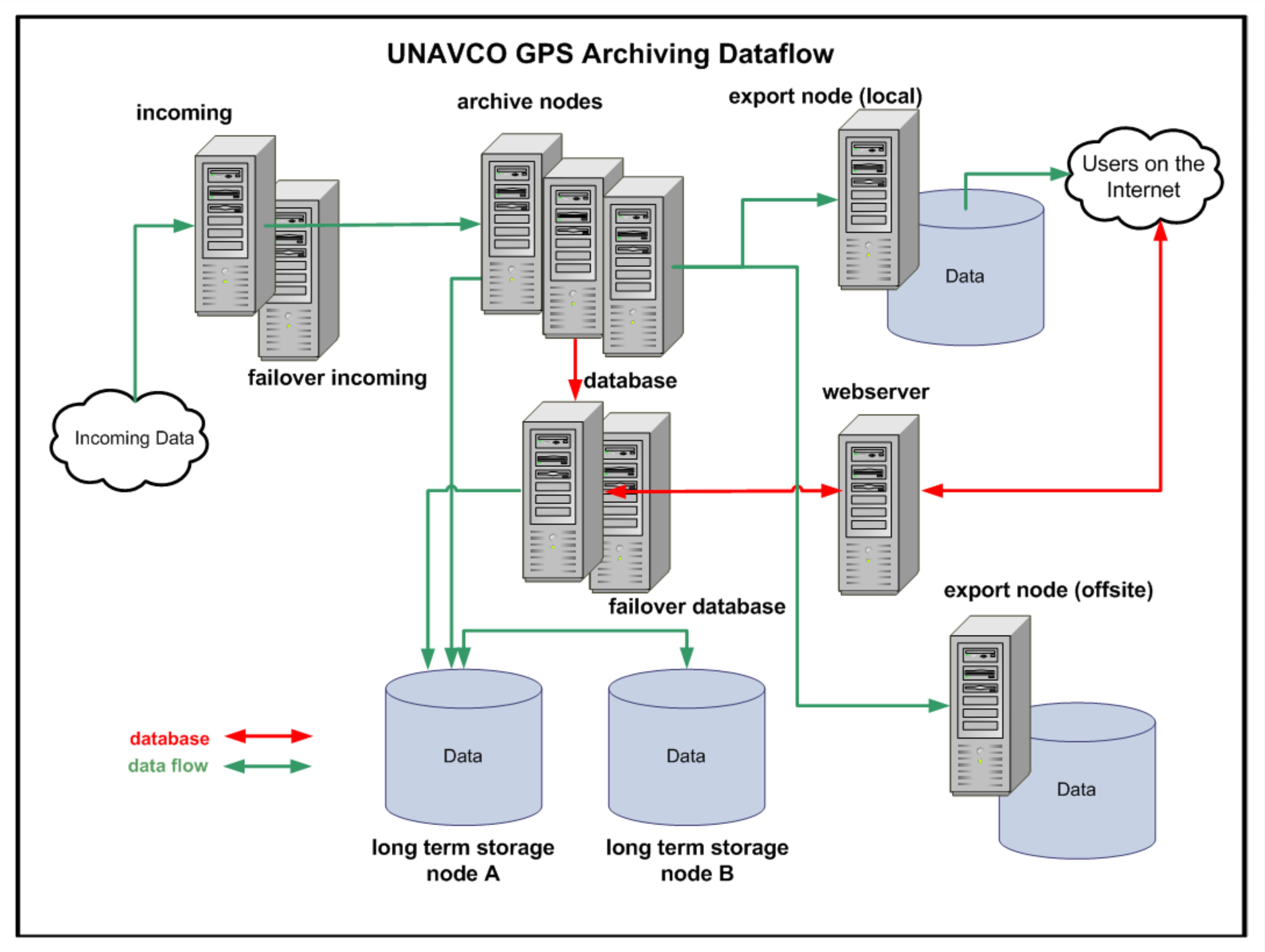
- Servers: Physical & Virtual Machines
- RAIDs, Storage Area Network
- Software
- Failover systems - onsite and offsite
- Onsite and offsite backup
- Cloud services

DATA MANAGEMENT FOR GPS/GNSS



Infrastructure

FUTURE DIRECTIONS AND DRIVERS



2020: Commercial Cloud Provider?

NSF Science Cloud?

2011: UNAVCO's Internal "Cloud"

Digital Object Identifiers for Data

OUTLINE

*UNAVCO Geodetic Data Infrastructure
Open data
Data Management
IT
Future directions and drivers

*Cyberinfrastructure
Web services APIs
GSAC
RESTful services
Collaboration across domains, institutions, and borders
Future directions and drivers

*Data Quality
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Techniques for QC and QA
Stations health and data quality
Future directions and drivers

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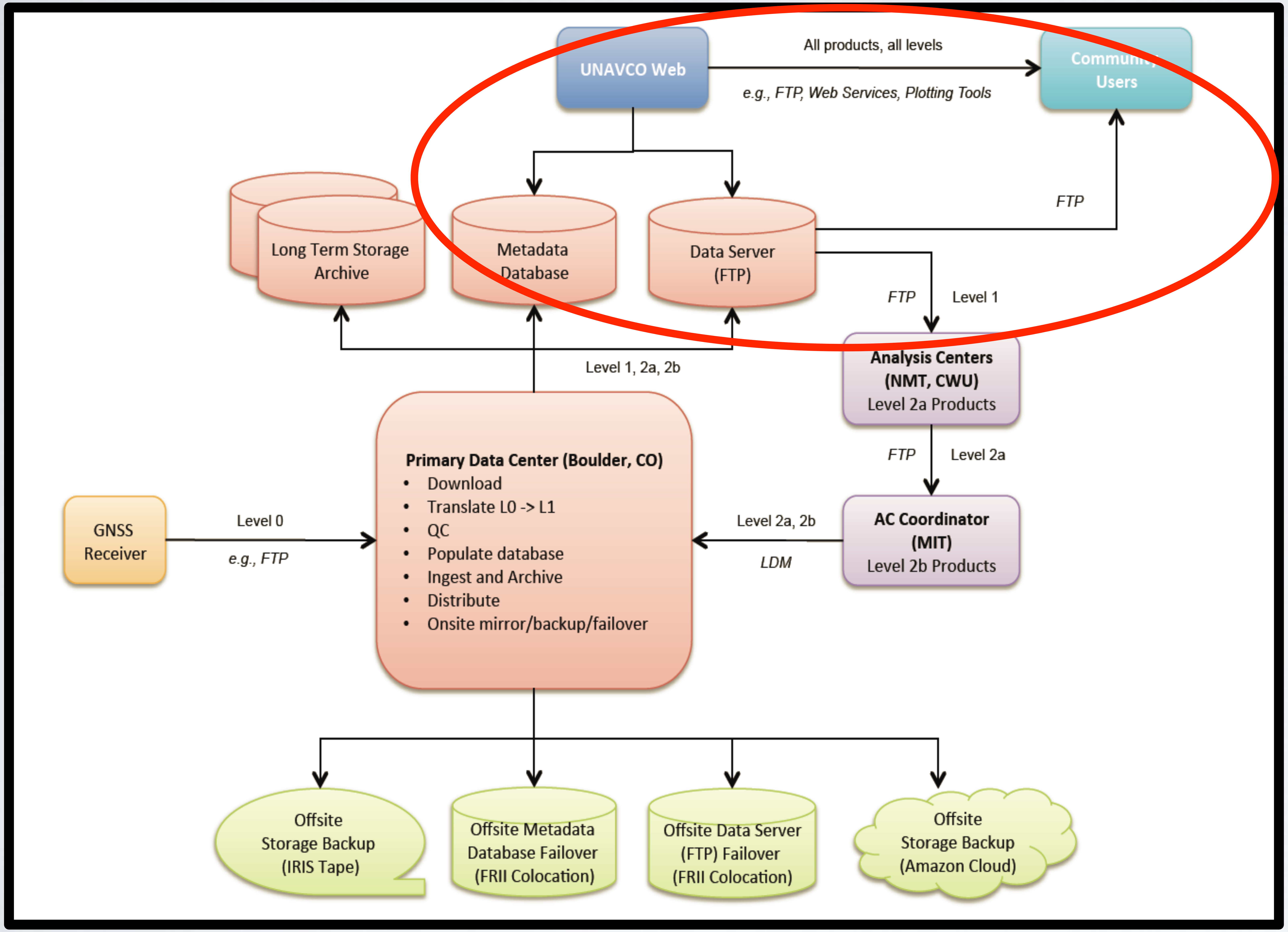
DATA ACCESS & CYBERINFRASTRUCTURE



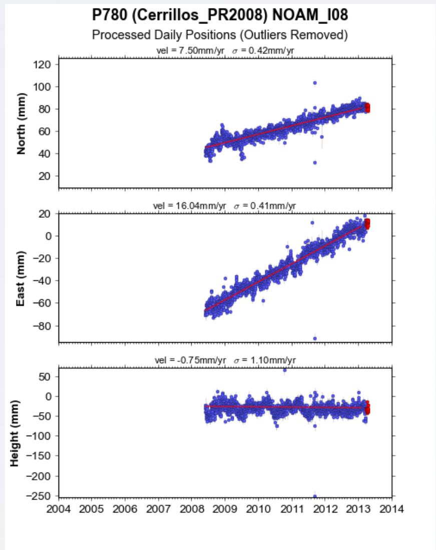
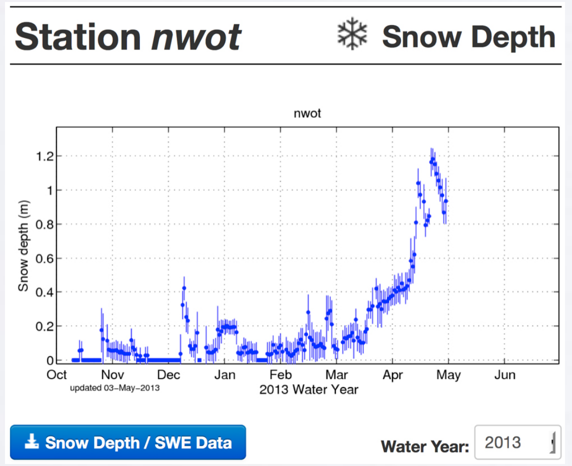
Data Access Traditional

- Data and Products via FTP
- Web User Interfaces For Search
- Visualization

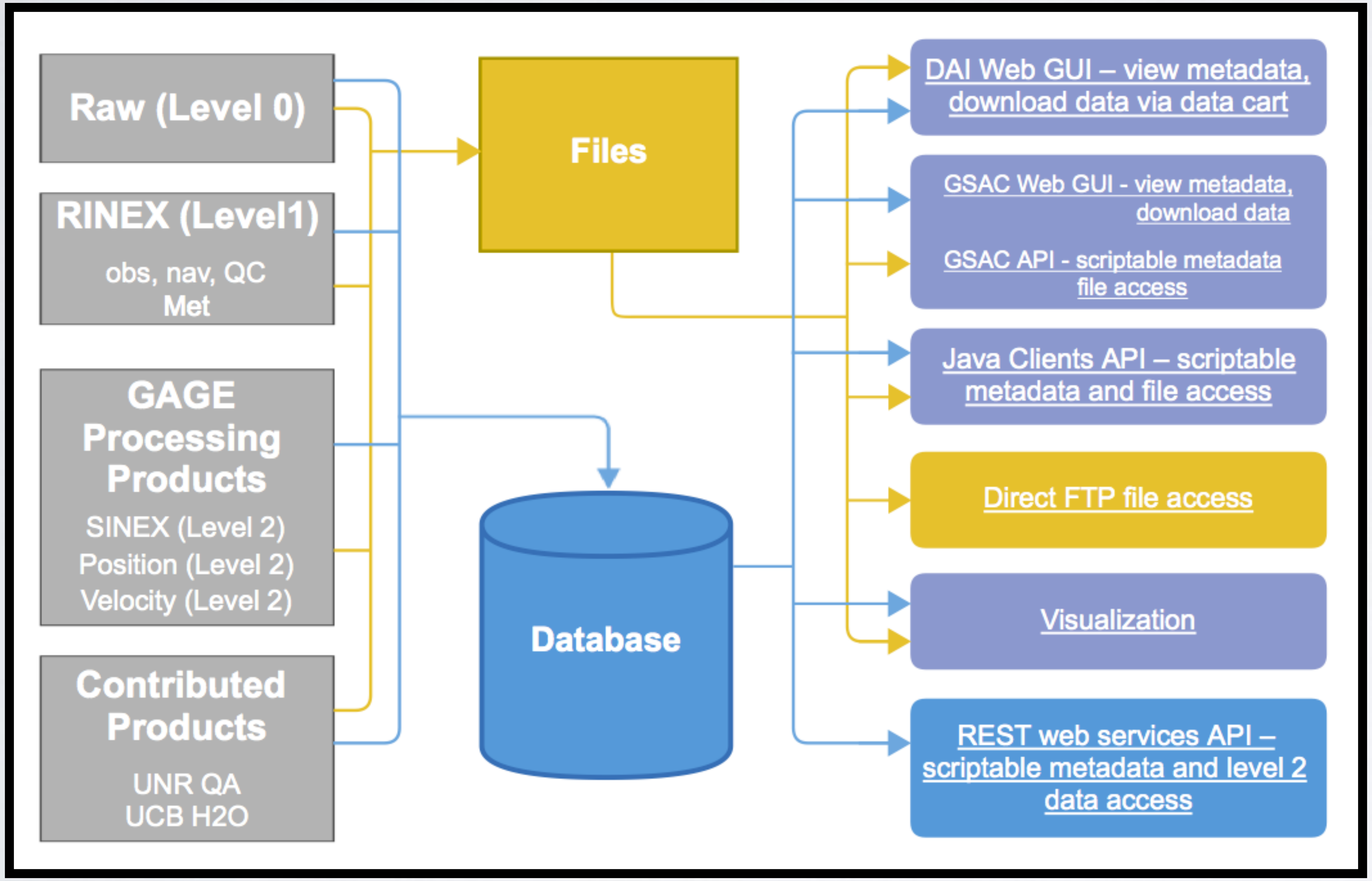
Data Access - Next Generation

- APIs
- Cross-domain Standardization

GPS DATA PRODUCT LEVELS

Level 0		*Raw data from instruments* *Metadata for GPS sites, sensors, and raw data*
Level 1		*Quality-checked data* *Translated files (Raw to RINEX)* *Metadata for QC, RINEX*
Level 2a		*Loosely constrained GPS position solutions and processing files* *Metadata for processing*
Level 2b		*GPS time series of daily data in multiple reference frames* *GPS station velocity solutions in multiple reference frames* *Event files (coseismic offsets)* *Metadata for processed data*
Level 3		*Derived products from processed data from the geodesy community*

DATA AND PRODUCT ACCESS

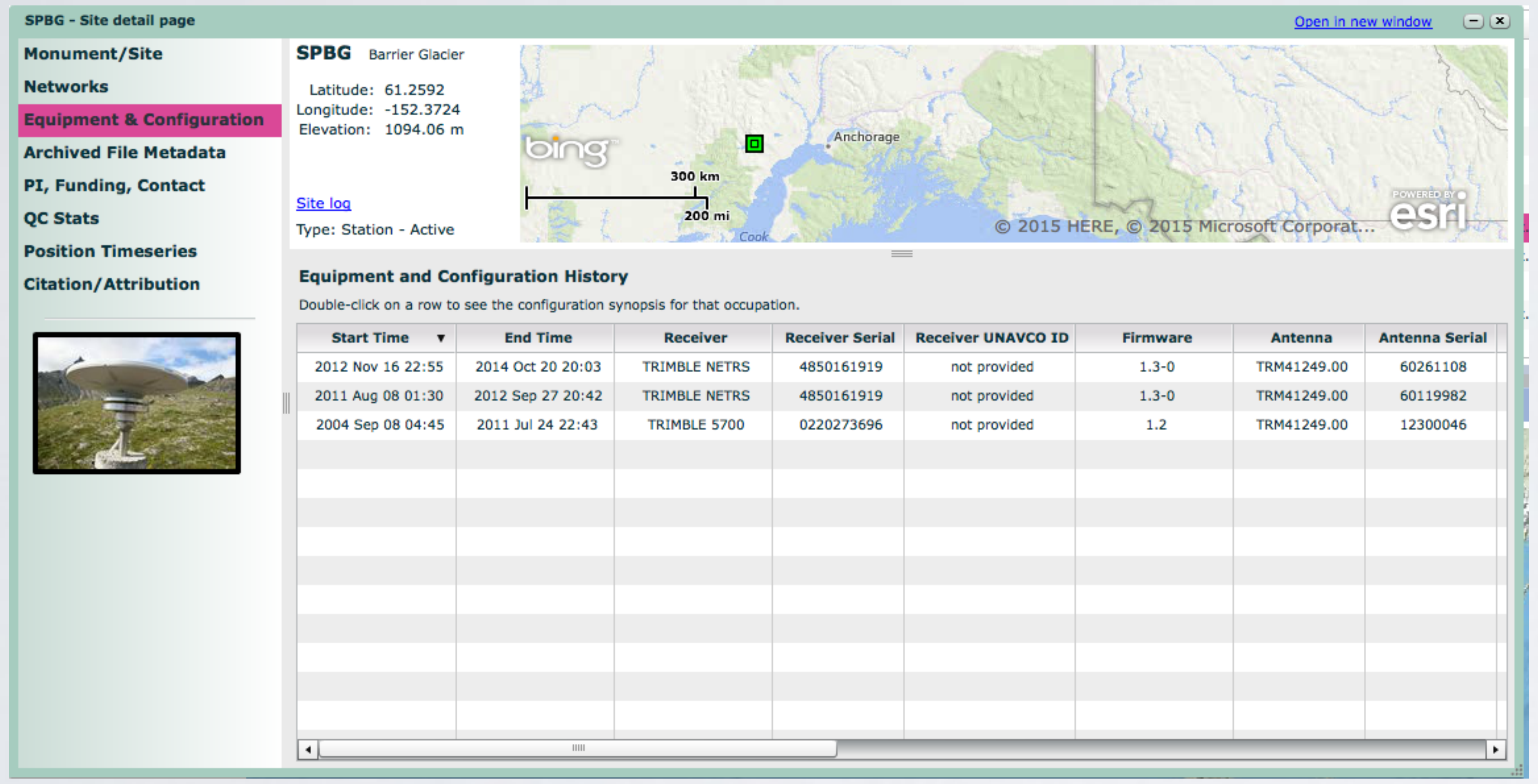


Data Access

- Raw data through products
- Products available as files by direct ftp or through web UI data cart
- Products available via web services: time series, reformatting
- Metadata viewable through web user interfaces
- Visualization
- Metadata accessible through web services in csv, SINEX, site log XML, JSON

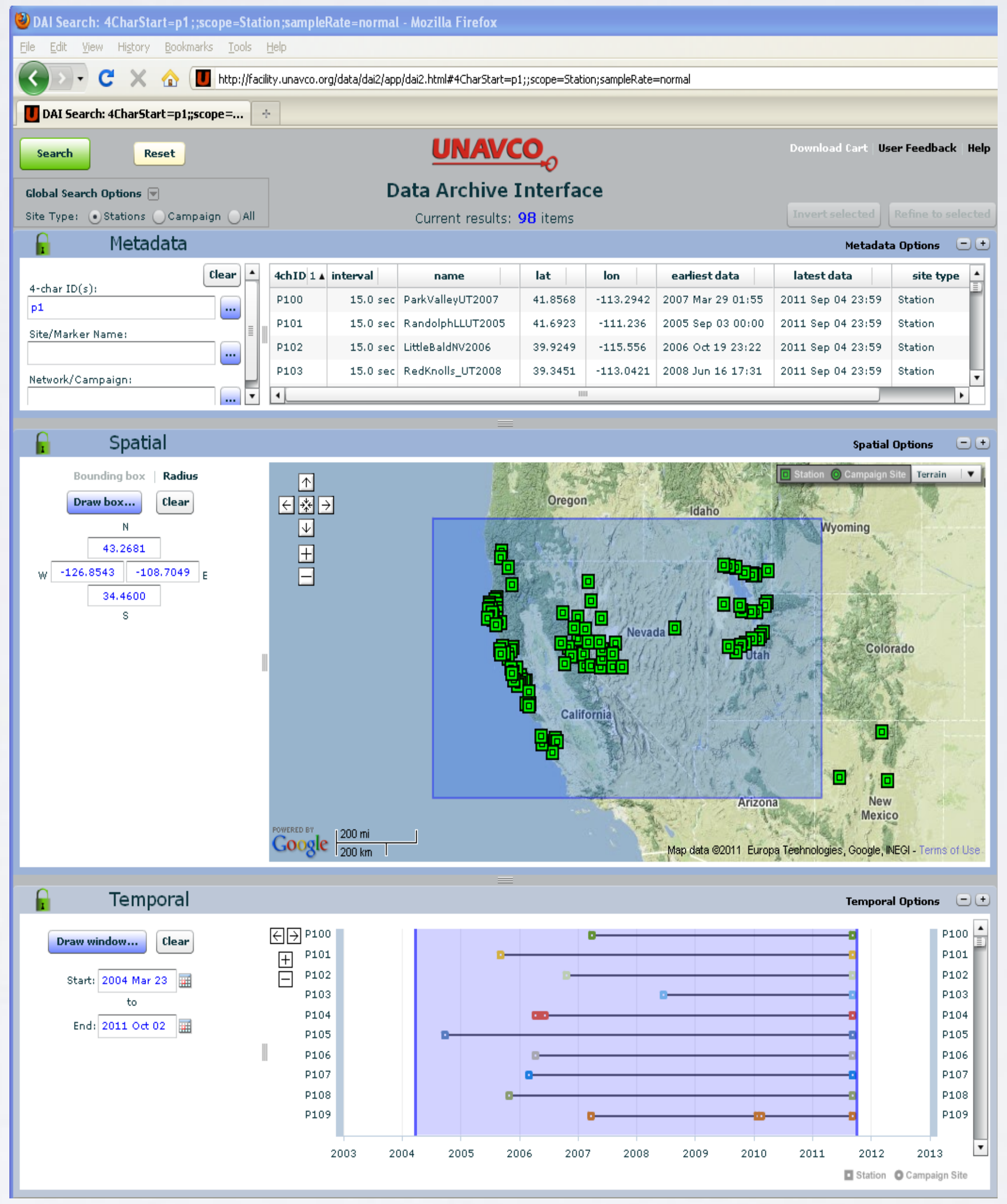
UNAVCO

ACCESS EXAMPLES

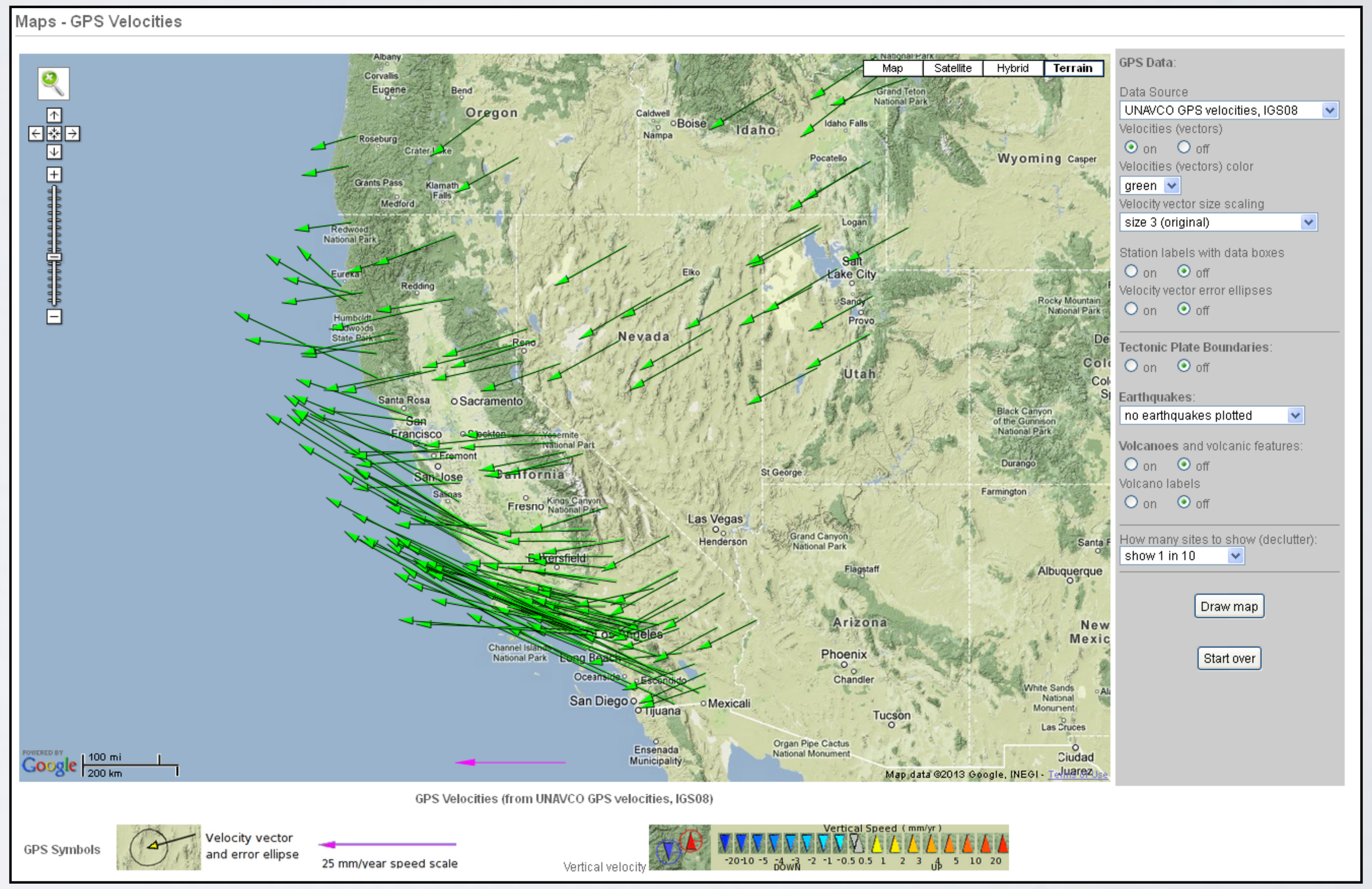


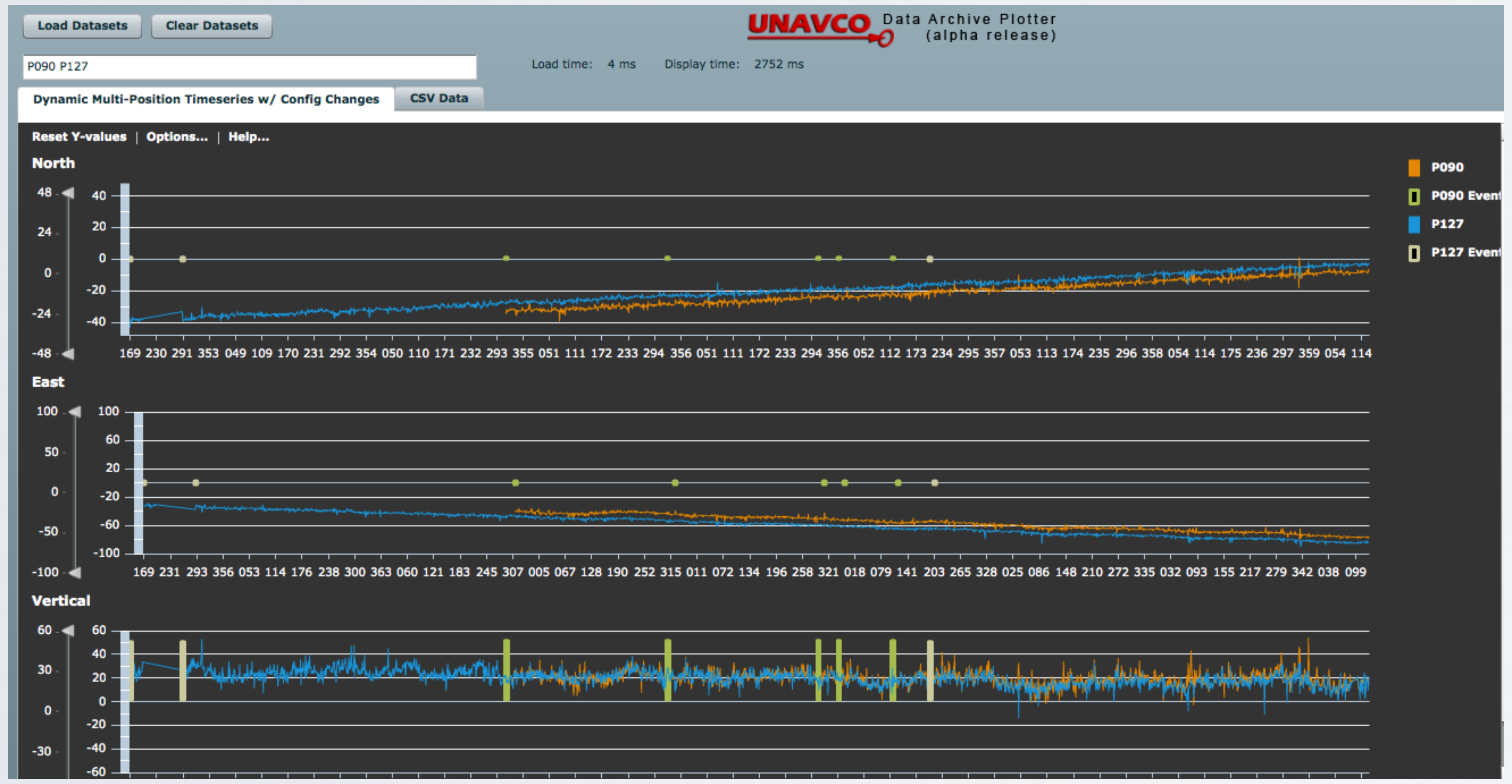
View metadata

Select stations

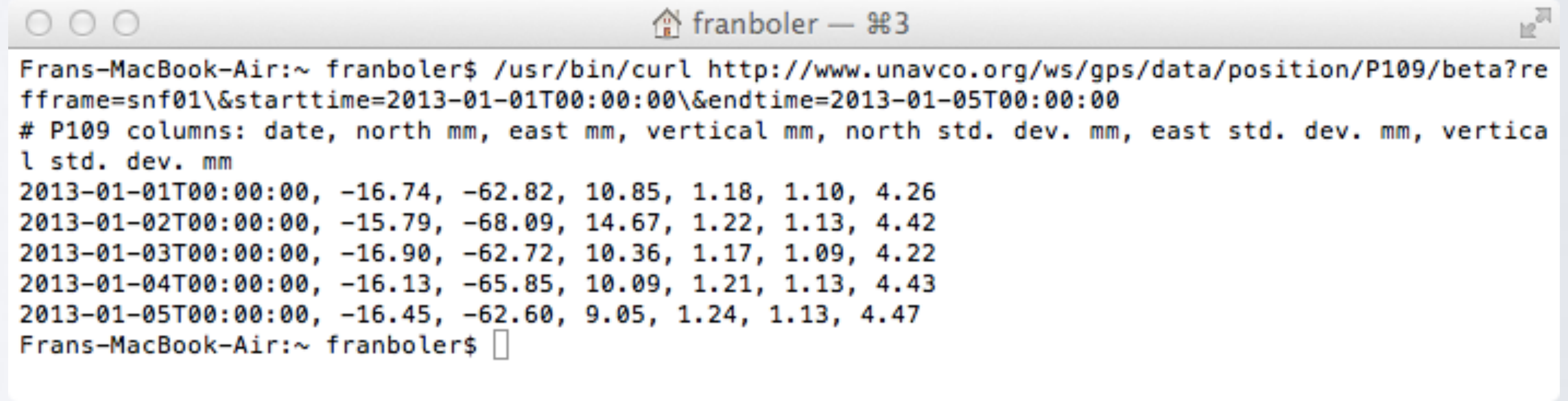


Visualization



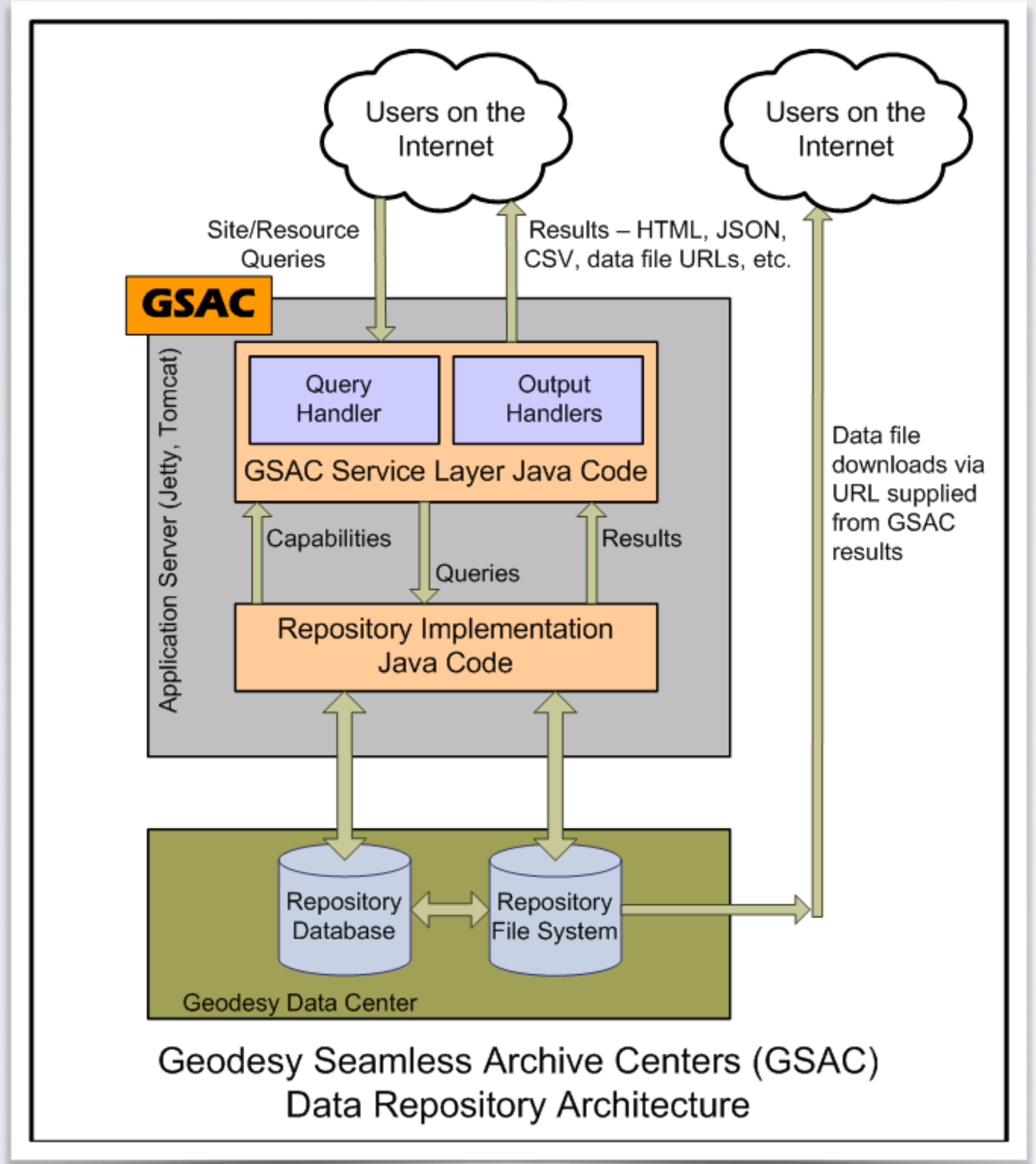


Interactive plotting



Web service delivers time series

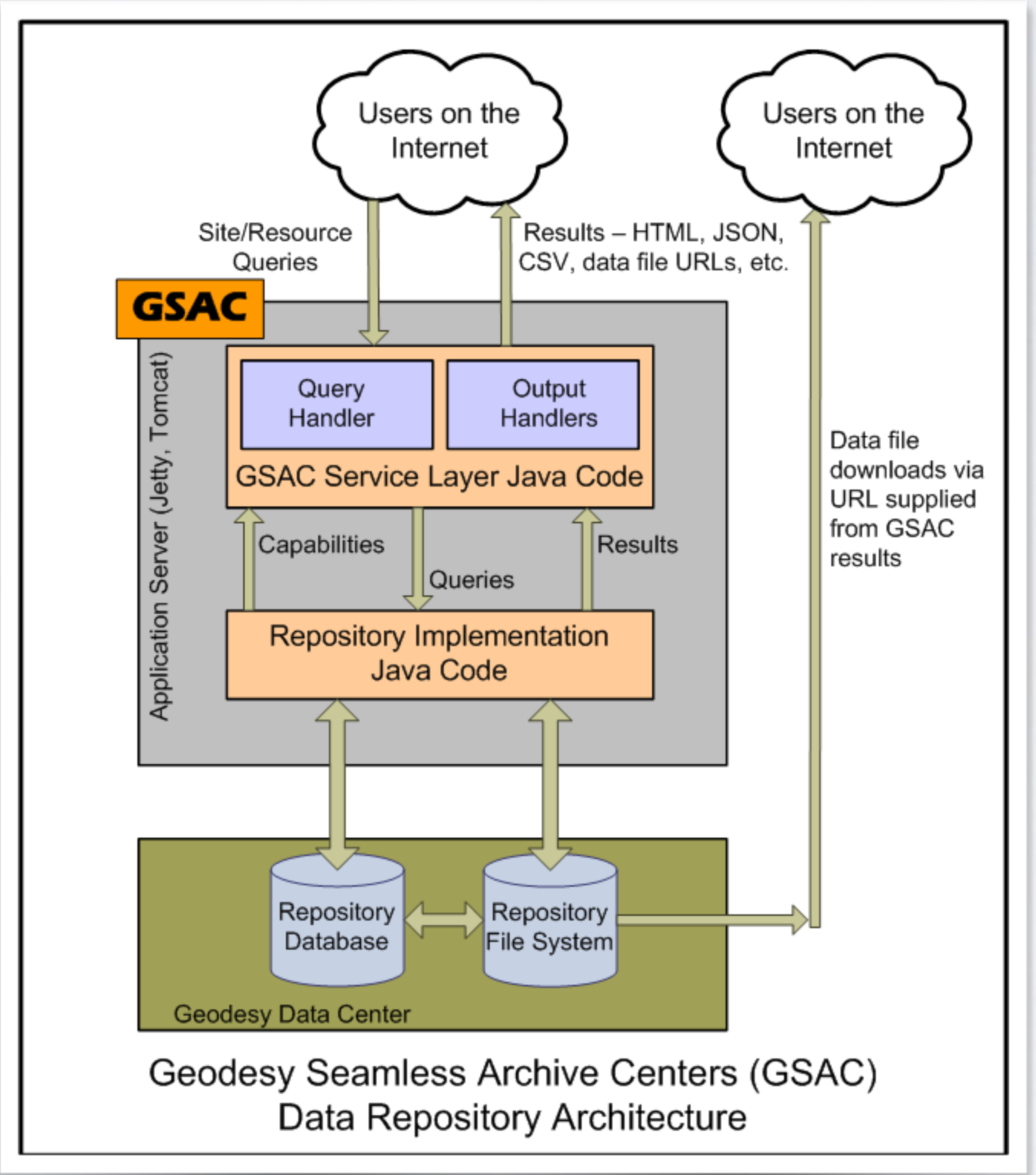
WEB SERVICES API FOR DATA SEARCH




```
>>>/usr/bin/curl http://facility.unavco.org/gsacws/gsacapi/site/search/
sites?output=site.csv\&site.type=gnss.site.continuous
\&site.interval=interval.normal
\&bbox.north=59.42\&bbox.south=59.32\&bbox.west=-153.6\&bbox.east=-153.3

#fields=ID[type='string'],station
name[type='string'],latitude,longitude,ellipsoid height[unit='m']
AUGL,Augustine Volcano Lower Mound,59.3703,-153.3539,104.0157
AV01,AV01AUGST_AK2004,59.3585,-153.4608,487.2244
AV02,AV02AUGST_AK2004,59.333,-153.4284,229.7855
AV03,AV03AUGST_AK2004,59.3813,-153.4378,360.1705
AV04,AV04AUGST_AK2004,59.3626,-153.4447,915.9493
AV05,AV05AUGST_AK2004,59.3629,-153.4227,1036.6063
AV11,Augs_MoundAK2006,59.3706,-153.3547,114.395
AV16,AugvLagoonAK2006,59.3859,-153.535,24.857
AV17,AugustinNWAK2006,59.4039,-153.4514,28.885
AV18,AugvNorth_AK2006,59.3804,-153.4368,366.697
AV19,AugustinSEAK2006,59.3549,-153.4143,646.938
AV20,Augs_SouthAK2006,59.3474,-153.4282,541.69
```

Retrieve station metadata

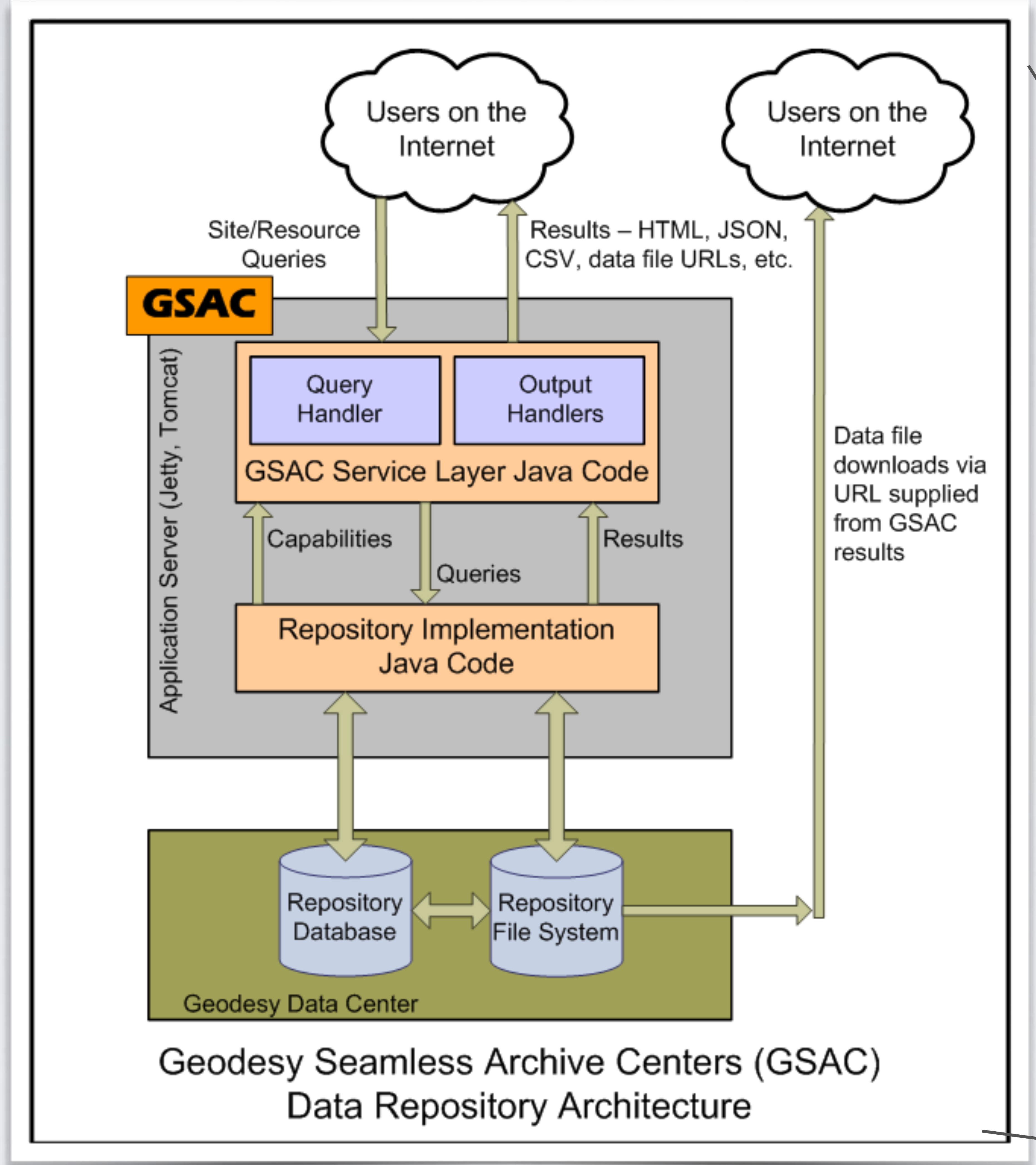
WEB SERVICES FOR DATA ACCESS

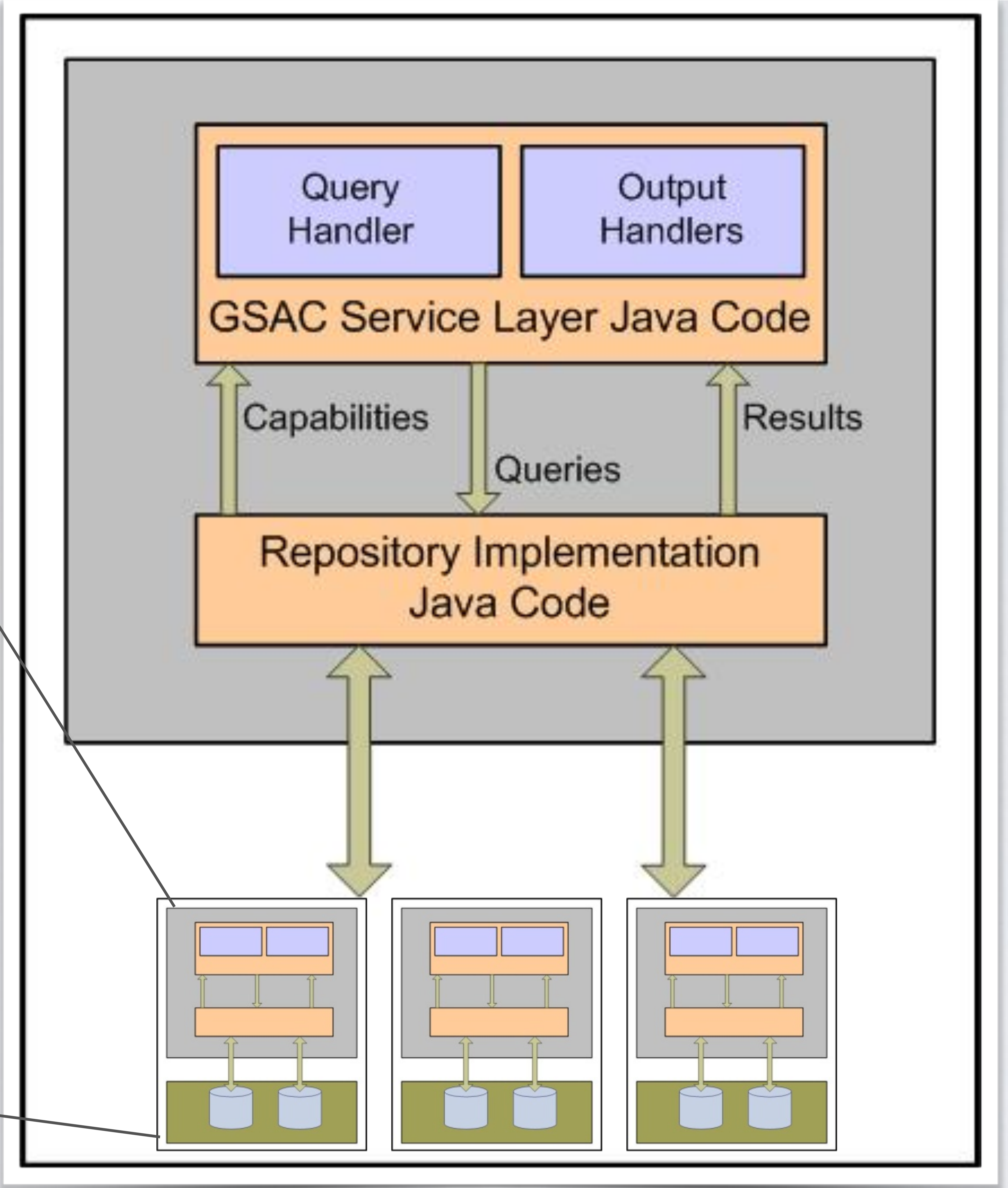



```
>>>/usr/bin/curl http://facility.unavco.org/gsacws/gsacapi/file/search?file.sortorder=descending\&
\&site.type=gnss.site.continuous\&file.type=gnss.data.rinex.navigation\&file.type=gnss.data.rinex.
\&file.datadate.from=2014-07-25\&file.datadate.to=2014-07-25
#fields=site_4char_ID[type='string'],Data_Type[type='string'],MD5[type='string'],FileSize[unit='by
HH:mm:ss'],URL[type='string'],dataStartTime[type='date' format='yyyy-MM-dd HH:mm:ss'],dataStopTime
HH:mm:ss'],sampleInterval[unit='s']
#   Comma-separated value file.  Missing metadata values have nothing between commas.
#   Generated by UNAVCO GSAC on 2015-05-25 18:00:31 +0000
CHIS,GNSS RINEX Observation (Hatanaka  Unix Compressed),1a4601f5e68f144485a0252044fd0ea2,834349,20
2014/206/chis2060.14d.Z,2014-07-25 00:00:00,2014-07-25 23:59:30,30.0,
CHIS,GNSS Navigation,72ef3c6dc2034160da0ae7fbb439c5fd,38070,2014-10-29 00:00:00,ftp://data-out.una
00:00:00,2014-07-25 23:59:30,30.0,
CHIS,GNSS Navigation,94fcf8be653a6c5db18a89d534fae230,37599,2014-10-29 00:00:00,ftp://data-out.una
00:00:00,2014-07-25 23:59:30,30.0,
CHIS,GNSS RINEX Meteorology,593448712f76cec832b5a4661bf4e5bd,19038,2014-10-29 00:00:00,ftp://data-
2014-07-25 00:00:00,2014-07-25 23:59:30,30.0,
```

Retrieve data/product files metadata and URL

DATA ACCESS: FEDERATION WITH WEB SERVICES





Cross-Institution Federation

RESTFUL WEB SERVICES FOR PRODUCTS

UNAVCO

Show/Hide | List Operations | Expand Operations | Raw

gps : GPS Services

GET **/gps/data/position/{station}/v1** Get the position time series for the specified station.

Implementation Notes

Retrieves the daily position time series for the station identified by four character id.

Returns: DateTime, North(mm), East(mm), Vertical(mm), North Std. Dev.(mm), East Std. Dev.(mm), Vertical Std. Dev.(mm), Solution

Response Class

string

Response Content Type text/csv

Parameters

Parameter	Value	Description	Parameter Type	Data Type
station	P378	**The four character station identifier.**	path	string
referenceFrame	nam08	The reference frame.	query	string
starttime	2006-01-01T00:00:00	**An ISO 8601 datetime indicating the start of the search range.**	query	Date
endtime	2012-03-01T00:00:00	**An ISO 8601 datetime indicating the end of the search range.**	query	Date
tsFormat	iso8601 (default)	The output time format. unixEpochMs is the no. of milliseconds from 1970-01-01T00:00:00.	query	string
stdDevRange	false (default)	Provides the values calculated by adding and subtracting 1 standard deviation from each corresponding value.	query	boolean

Response Messages

HTTP Status Code	Reason	Response Model
404	Invalid Station Id supplied.	
400	Invalid query parameters.	

Try it out!

Try it out! Hide Response

Request URL

```
http://web-services.unavco.org:80/gps/data/position/P378/v1?referenceFrame=nam08&starttime=2006-01-01T00%3A00%3A00&endtime=2012-0
```

Response Body

```
# P378: DateTime, North(mm), East(mm), Vertical(mm), North Std. Dev.(mm), East Std. Dev.(mm), Vertical Std. Dev.(mm), Quality
2007-06-27T00:00:00, -21.55, -11.61, -1.73, 3.74, 2.27, 10.70, repro
2007-06-28T00:00:00, -23.01, -13.45, 1.32, 1.68, 1.31, 5.52, repro
2007-06-29T00:00:00, -21.10, -12.62, -9.94, 1.78, 1.38, 5.85, repro
2007-06-30T00:00:00, -22.42, -12.67, -1.16, 1.44, 1.13, 4.75, repro
2007-07-01T00:00:00, -22.11, -12.95, 3.07, 1.58, 1.24, 5.21, repro
2007-07-02T00:00:00, -21.65, -14.02, 1.53, 1.76, 1.37, 5.78, repro
2007-07-03T00:00:00, -22.29, -13.70, 2.36, 1.46, 1.15, 4.81, repro
2007-07-04T00:00:00, -21.81, -13.69, 2.97, 1.47, 1.16, 4.84, repro
2007-07-05T00:00:00, -21.72, -12.76, -2.23, 1.85, 1.42, 6.00, repro
2007-07-06T00:00:00, -21.53, -13.42, -1.51, 1.62, 1.30, 5.36, repro
2007-07-07T00:00:00, -21.07, -12.97, -1.37, 1.71, 1.37, 5.64, repro
2007-07-08T00:00:00, -22.30, -13.29, -0.78, 1.64, 1.34, 5.47, repro
2007-07-09T00:00:00, -22.11, -12.38, -1.04, 1.44, 1.17, 4.79, repro
2007-07-10T00:00:00, -23.06, -12.40, 0.82, 1.81, 1.44, 6.01, repro
2007-07-11T00:00:00, -22.08, -14.33, 7.00, 1.69, 1.34, 5.61, repro
2007-07-12T00:00:00, -20.96, -12.88, 0.04, 1.91, 1.51, 6.33, repro
2007-07-13T00:00:00, -21.97, -13.89, 2.76, 1.92, 1.54, 6.41, repro
2007-07-14T00:00:00, -23.45, -13.71, 7.51, 1.85, 1.47, 6.13, repro
2007-07-15T00:00:00, -21.78, -12.73, 7.18, 1.99, 1.58, 6.62, repro
2007-07-16T00:00:00, -22.31, -13.14, 5.29, 1.89, 1.50, 6.27, repro
2007-07-17T00:00:00, -22.94, -12.67, 5.35, 1.96, 1.55, 6.51, repro
2007-07-18T00:00:00, -22.96, -13.49, 5.19, 1.94, 1.53, 6.41, repro
2007-07-19T00:00:00, -22.22, -13.06, 0.75, 1.60, 1.28, 5.31, repro
```

Retrieve Position Time Series, Velocities, or Metadata

FUTURE DIRECTIONS AND DRIVERS

Cyberinfrastructure for Interoperability

- Cross-institution (GSAC in the US: SOPAC, CDDIS, UNAVCO)
- Cross-borders (GSAC within EPOS: France, Italy, Greece, Iceland, Spain…) (GSAC within Regional Data Centers COCONet, TLALOCNet)
- Cross-domain (EarthCube, COOPEUS, and GEO)

OUTLINE

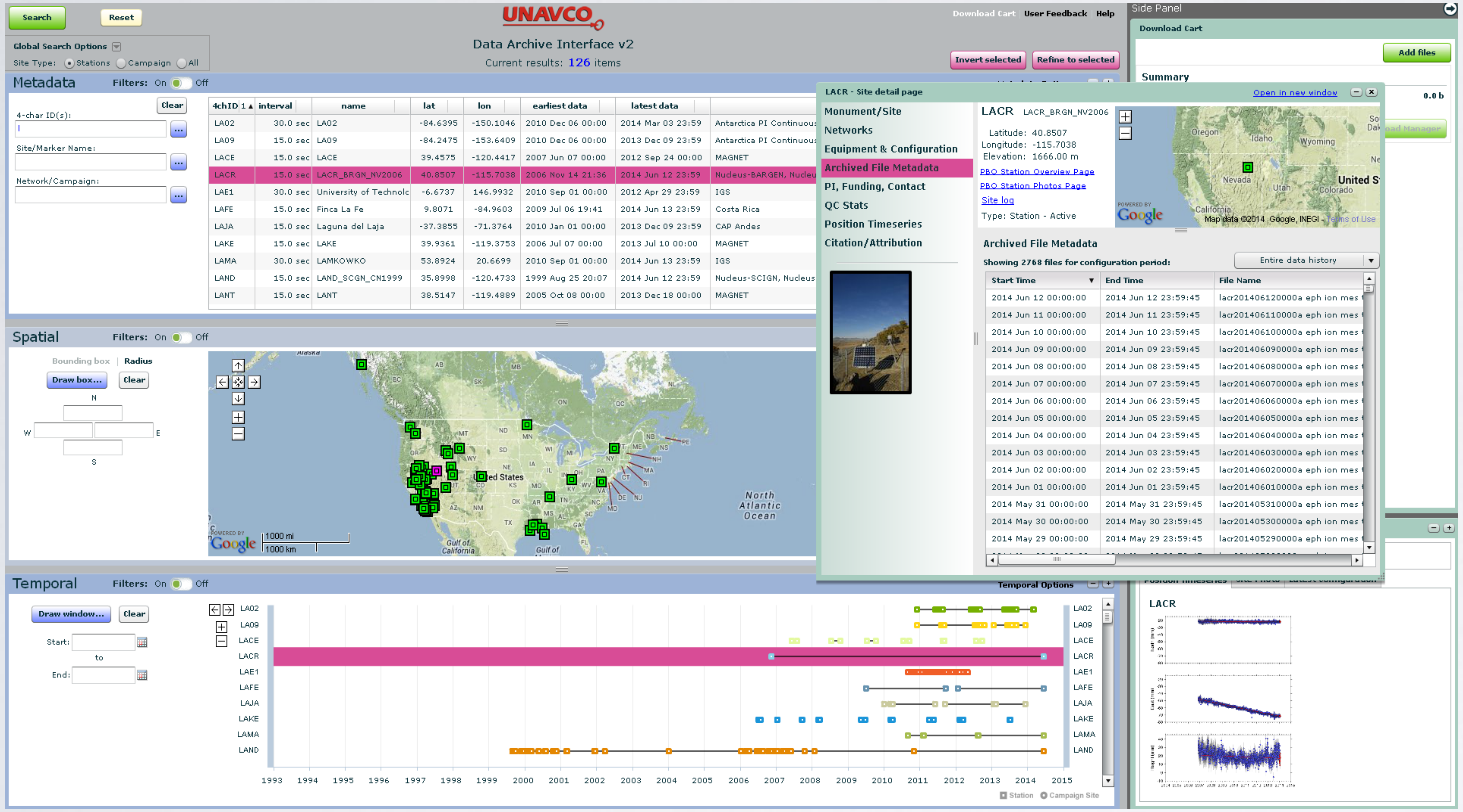
*UNAVCO Geodetic Data Infrastructure
Open data
Data Management
IT
Future directions and drivers

*Cyberinfrastructure
Web services APIs
GSAC
RESTful services
Collaboration across domains, institutions, and borders
Future directions and drivers

*Data Quality
Metadata management
Techniques for QC and QA
Stations health and data quality
Future directions and drivers

UNAVCO

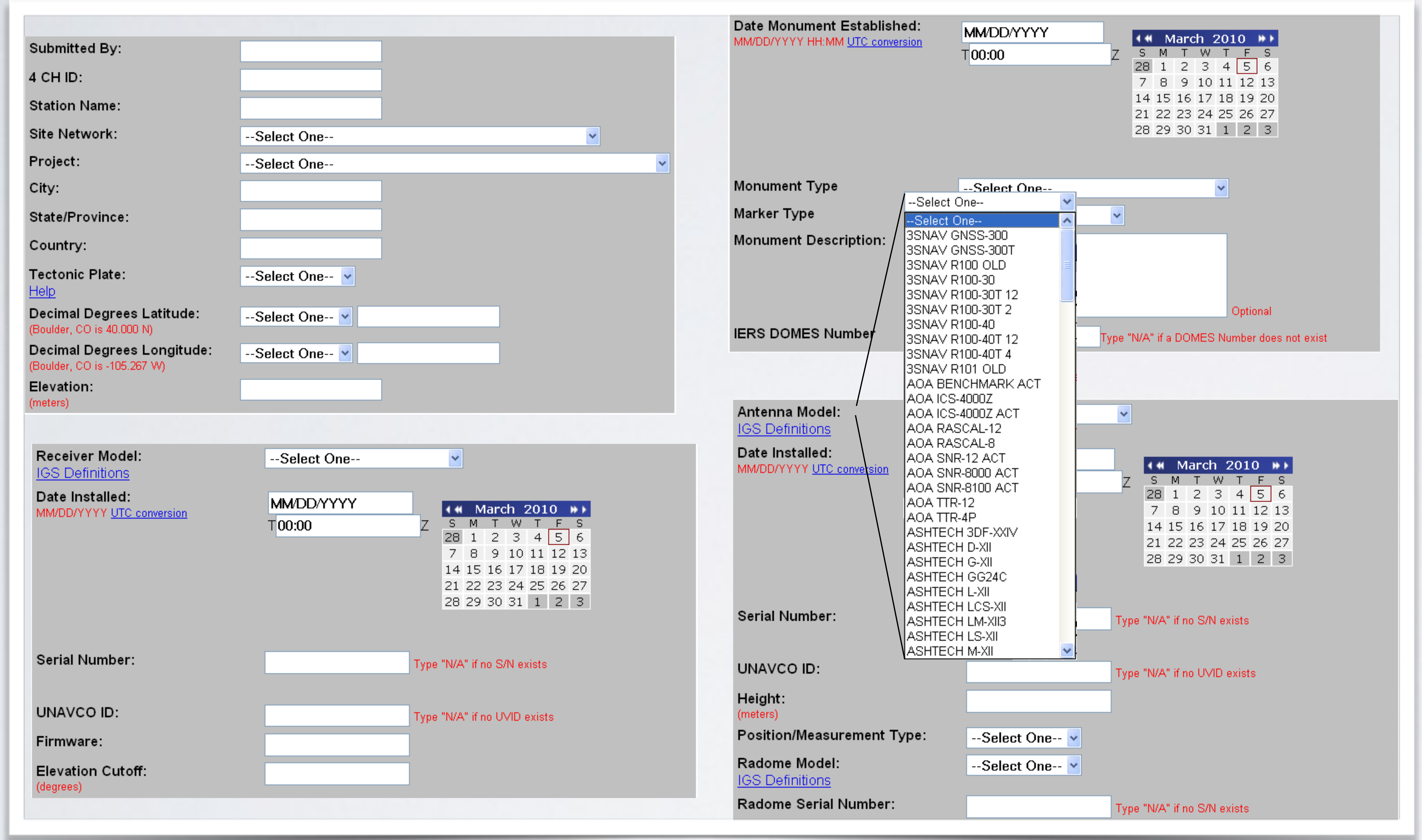
ENGINEERING METADATA MANAGEMENT



Attention to Engineering Metadata

- Installation standards (“pre metadata”)
- Definition
- Tools to gather
- Timeliness
- Business rules
- Automated consistency checks
- Human verification

METADATA ENTRY TOOLS



Tools to facilitate

- Timeliness
- Business rules
- Internal consistency checks
- Standards

METADATA ACCESS

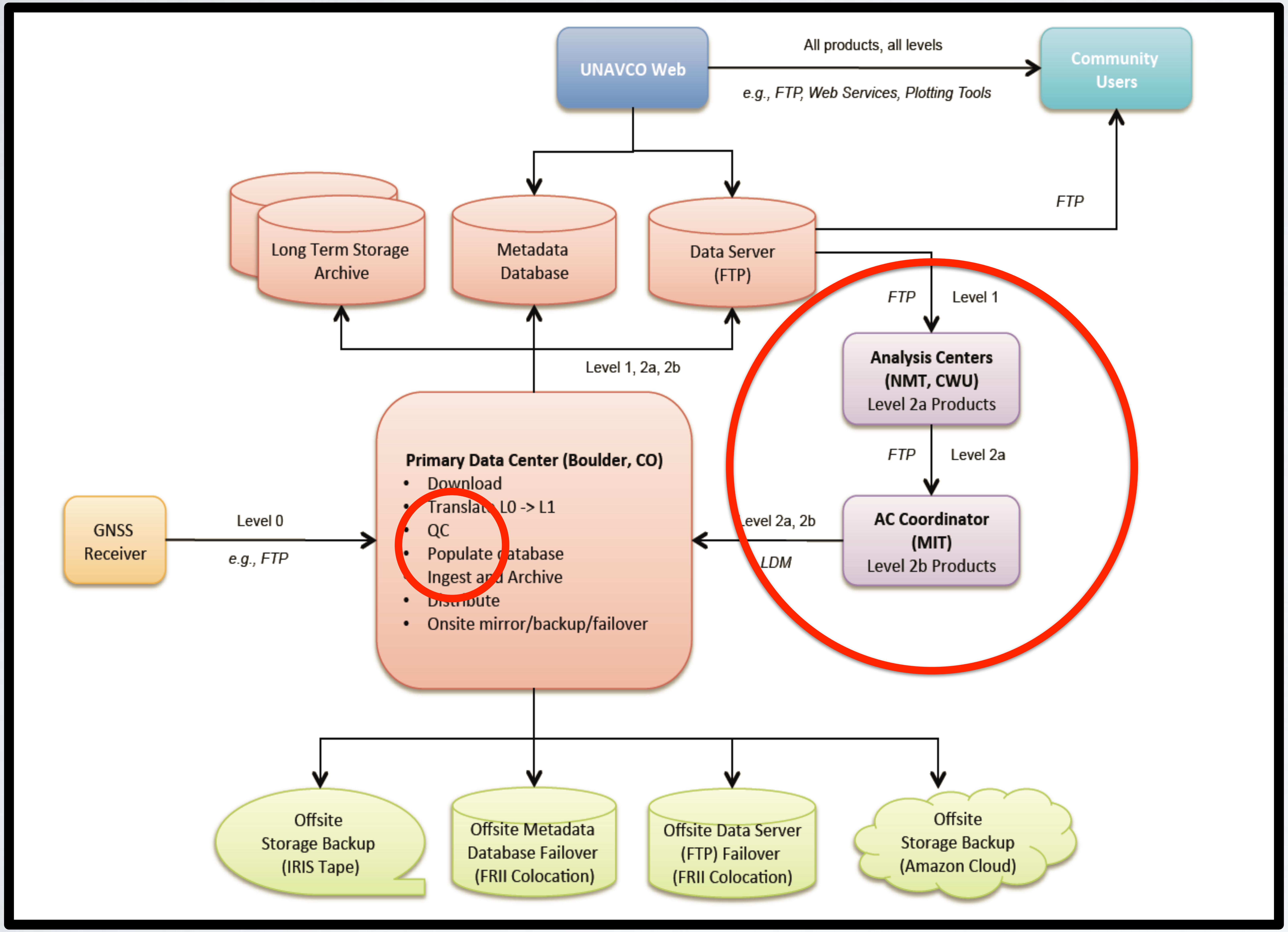
- When is the right time to access metadata?
- Where should it be obtained?

```
     2.11           OBSERVATION DATA    G (GPS)             RINEX VERSION / TYPE
teqc  2010Mar4      UNAVCO Archive Ops  20100307 02:07:44UTCPGM / RUN BY / DATE
Solaris 5.10|UltraSparc IIIi|cc -xarch=v9 SC5.8|=+|*Sparc  COMMENT
BIT 2 OF LLI FLAGS DATA COLLECTED UNDER A/S CONDITION      COMMENT
ALUT                                                        MARKER NAME
                                                            MARKER NUMBER
Robert B. Smith     University of Utah                      OBSERVER / AGENCY
4539258391          TRIMBLE NETRS       1.1-3               REC # / TYPE / VERS
0220335602          TRM29659.00     SCIT                    ANT # / TYPE
 -1788072.1001 -4511503.4868  4129277.8016                  APPROX POSITION XYZ
        0.0000        0.0000        0.0000                  ANTENNA: DELTA H/E/N
     1     1                                                WAVELENGTH FACT L1/2
     7    L1    L2    C1    P2    P1    S1    S2            # / TYPES OF OBSERV
    30.0000                                                 INTERVAL
RINEX file created by UNAVCO GPS Archive.                   COMMENT
For more information contact archive@unavco.org             COMMENT
Monument ID: 19258                                          COMMENT
UNAVCO 4-char name:   ALUT                                  COMMENT
4-char name from Log or data file: ALUT                     COMMENT
Monument location: 40.58390772 -111.620214888 2824.077      COMMENT
Visit ID: 86961                                             COMMENT
End of DB comments                                          COMMENT
 SNR is mapped to RINEX snr flag value [0-9]                COMMENT
  L1 & L2: min(max(int(snr_dBHz/6), 0), 9)                  COMMENT
  2010     3     6     0     0    0.0000000     GPS         TIME OF FIRST OBS
                                                            END OF HEADER
 10  3  6  0  0  0.0000000  0  6G23G20G31G16G14G11
 124669172.729 7   97144769.75944   23723748.705      23723738.4274
```

```
     ALUT Site Information Form (site log)
     International GPS Service
     See Instructions at:
       ftp://igscb.jpl.nasa.gov/pub/station/general/site

0.   Form

     Prepared by (full name)   : Susan Jeffries
     Date Prepared             : 2008-04-08
     Report Type               : UPDATE
     If Update:
      Previous Site Log        : alut_20060907.log
      Modified/Added Sections  : (n.n,n.n,...)


1.   Site Identification of the GNSS Monument

     Site Name                 : Alta, Utah
     Four Character ID         : ALUT
     Monument Inscription      :
     IERS DOMES Number         : (A9)
     CDP Number                : (A4)
     Monument Description      : PERMANENT STATION UNSPE
       Height of the Monument  : (m)
       Monument Foundation     : UNKNOWN
       Foundation Depth        : (m)
     Marker Description        : UNKNOWN
     Date Installed            : 2005-07-20
     Geologic Characteristic   : (BEDROCK/CLAY/CONGLOMER
       Bedrock Type            : (IGNEOUS/METAMORPHIC/SE
       Bedrock Condition       : (FRESH/JOINTED/WEATHERE
       Fracture Spacing        : (1-10 cm/11-50 cm/51-20
       Fault zones nearby      : (YES/NO/Name of the zon
         Distance/activity     : (multiple lines)
     Additional Information    : (multiple lines)

2.   Site Location Information

     City or Town              : Alta
     State or Province         : Utah
     Country                   : United States
```

```
#fields=ID[type='string'],station_name[type='string'],latitude,longitude,ellip_height[unit='m'],monument_description[type='string'],IERSDOMES[type='string'],session_start_time[type='date' format='yyyy-MM-ddTHH:mm:ss zzzzz'],session_stop_time[type='date' format='yyyy-MM-ddTHH:mm:ss zzzzz'],antenna_type[type='string'],dome_type[type='string'],antenna_SN[type='string'],Ant_dZ,Ant_dN,Ant_dE,receiver_type[type='string'],firmware_version[type='string'],receiver_SN[type='string'],sample_interval,city_locale[type='string'],state_prov[type='string'],country[type='string'],X,Y,Z,agencyname[type='string'],metpackname[type='string'],metpackSN[type='string'],site_count
#   Generated by UNAVCO GSAC Repository on 2015-03-31T15:42:29
#   Missing times (no characters) may mean 'not removed' or 'no change.'
#   The CSV convention for point data is CF for CSV. See http://ramadda.org/repository/entry/show/Home/RAMADDA+Information/Development/CF+for+CSV?entryid=23652828-c6f4-482b-bb2f-041dae14542e
1LSU,Louisiana State University,30.4074,-91.1803,-6.44,shallow foundation mast,,2003-04-23T00:00:00,2003-12-05T23:59:45,ASH701945E_M,SCIS,620024327,0.0000,0.0000,0.0000,ASHTECH UZ-12,CN00,2200252004,,Baton Rouge,Louisiana,United States,,,,,,,1
1LSU,Louisiana State University,30.4074,-91.1803,-6.44,shallow foundation mast,,2003-12-06T07:36:15,2005-06-15T23:59:45,ASH701945E_M,SCIS,620024327,0.0000,0.0000,0.0000,ASHTECH UZ-12,CN00,2200252006,,Baton Rouge,Louisiana,United States,,,,,,,1
1LSU,Louisiana State University,30.4074,-91.1803,-6.44,shallow foundation mast,,2005-06-16T21:10:40,2005-09-08T23:59:59,ASH701945E_M,SCIS,620024327,0.0000,0.0000,0.0000,ASHTECH UZ-12,CQ00,2200252006,,Baton Rouge,Louisiana,United States,,,,,,,1
1LSU,Louisiana State University,30.4074,-91.1803,-6.44,shallow foundation mast,,2006-05-12T00:00:00,2006-11-10T23:59:30,ASH701945E_M,SCIS,620024327,0.0000,0.0000,0.0000,TRIMBLE NETRS,1.1-3,45492612640,Baton Rouge,Louisiana,United States,,,,,,,1
1LSU,Louisiana State University,30.4074,-91.1803,-6.44,shallow foundation mast,,2006-11-11T00:00:00,2008-06-20T21:08:00,ASH701945E_M,SCIS,620024327,0.0000,0.0000,0.0000,TRIMBLE NETRS,1.1-5,45492612640,Baton Rouge,Louisiana,United States,,,,,,,1
1LSU,Louisiana State University,30.4074,-91.1803,-6.44,shallow foundation mast,,2008-06-23T17:20:30,2008-11-19T16:59:30,TRM57971.00,NONE,30765370,0.0000,0.0000,0.0000,TRIMBLE NETRS,1.2-0,4635120813,3Baton Rouge,Louisiana,United States,,,,,,,1
1LSU,Louisiana State University,30.4074,-91.1803,-6.44,shallow foundation mast,,2008-12-10T12:00:00,2009-07-26T23:59:30,TRM57971.00,NONE,30765370,0.0000,0.0000,0.0000,TRIMBLE NETR5,3.64,4807K53479,30aton Rouge,Louisiana,United States,,,,,,,1
1LSU,Louisiana State University,30.4074,-91.1803,-6.44,shallow foundation mast,,2009-07-27T00:00:00,2010-04-11T12:59:30,TRM57971.00,NONE,30765370,0.0000,0.0000,0.0000,TRIMBLE NETR5,4.03,4807K53479,30aton Rouge,Louisiana,United States,,,,,,,1
1LSU,Louisiana State University,30.4074,-91.1803,-6.44,shallow foundation mast,,2010-04-14T16:00:00,2010-08-25T23:59:30,TRM41249.00,NONE,60104339,0.0000,0.0000,0.0000,TRIMBLE NETRS,1.2-0,4635120799,3Baton Rouge,Louisiana,United States,,,,,,,1
1LSU,Louisiana State University,30.4074,-91.1803,-6.44,shallow foundation mast,,2010-08-26T00:00:00,2014-01-14T23:59:30,TRM41249.00,NONE,60104339,0.0000,0.0000,0.0000,TRIMBLE NETRS,1.3-0,4635120799,3Baton Rouge,Louisiana,United States,,,,,,,1
1LSU,Louisiana State University,30.4074,-91.1803,-6.44,shallow foundation mast,,2014-01-15T00:00:00,2014-07-08T10:59:30,TRM57971.00,NONE,5000117882,0.0000,0.0000,0.0000,TRIMBLE NETR9,4.81,5201K41202,,Baton Rouge,Louisiana,United States,,,,,,,1
1LSU,Louisiana State University,30.4074,-91.1803,-6.44,shallow foundation mast,,2014-07-30T17:04:30,2015-03-29T23:59:30,TRM57971.00,NONE,5000117882,0.0000,0.0000,0.0000,TRIMBLE NETR9,4.85,5201K41202,,Baton Rouge,Louisiana,United States,,,,,,,1
```

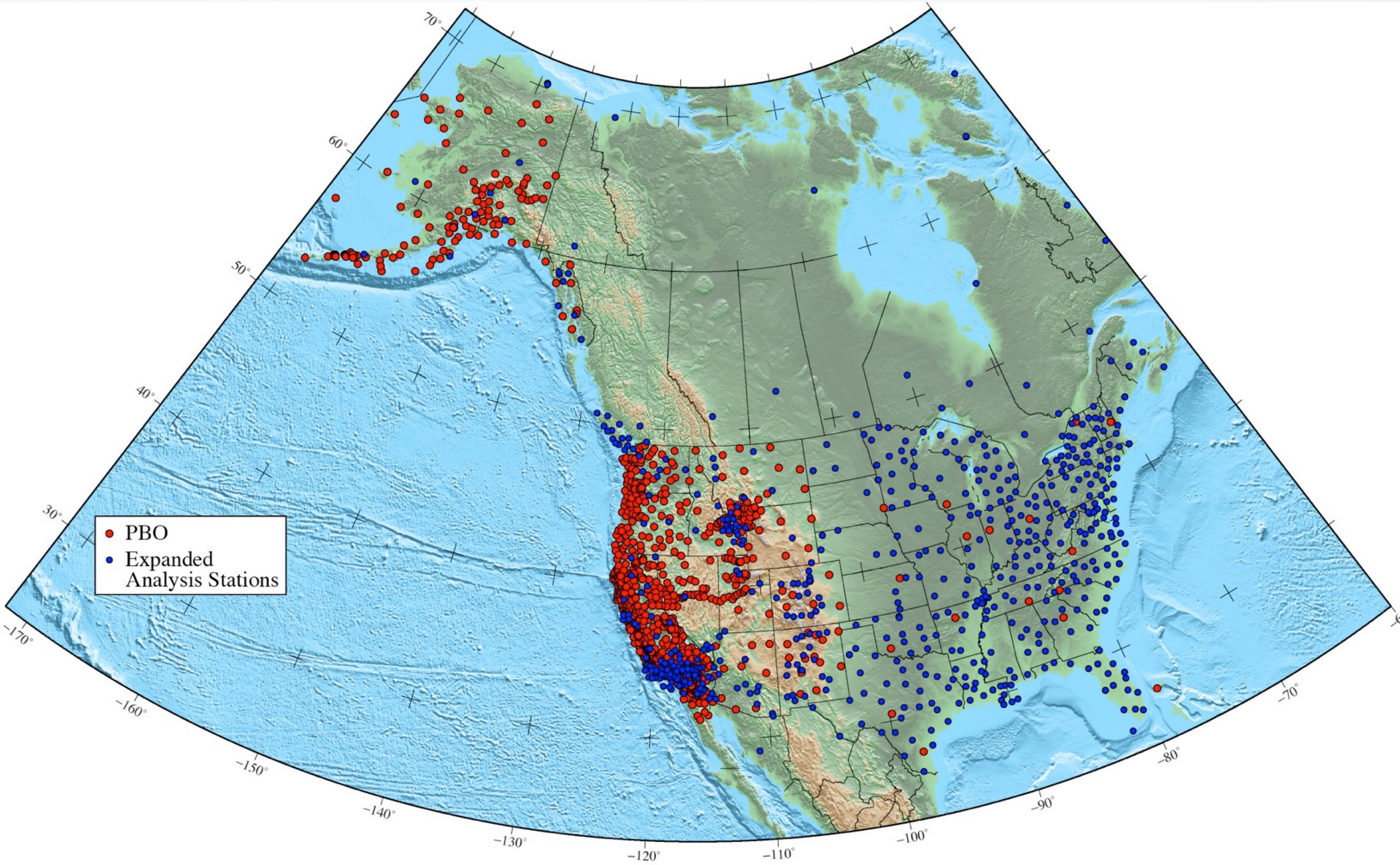
QA/QC AND PROCESSING



- QC preprocessing via TEQC - all incoming data
- Selected processing by GAGE Analysis Centers
- Post-processing by University of Nevada Reno

EXPANDED GPS DATA ANALYSIS

- >1,800 GPS stations analyzed by GAGE AC's
- 1,100 official PBO plus COCONet, SCIGN, TLALOCNet and "Expanded Analysis" stations from complementary networks, mostly NGS CORS
- Daily positions, time series and velocities provided in IGS08 and NAM08 reference frames
- NAM08 has replaced SNF01; realized by rotating ITRF2008 to North America using the Euler vector published by Altimimi et al. (2012); reduces errors from relative phase center models or GIA modeling; ongoing tweaks by ACC...official announcement and documentation coming



UNAVCO

EXPANDED GPS DATA ANALYSIS

- >1,800 GPS stations analyzed by GAGE AC's
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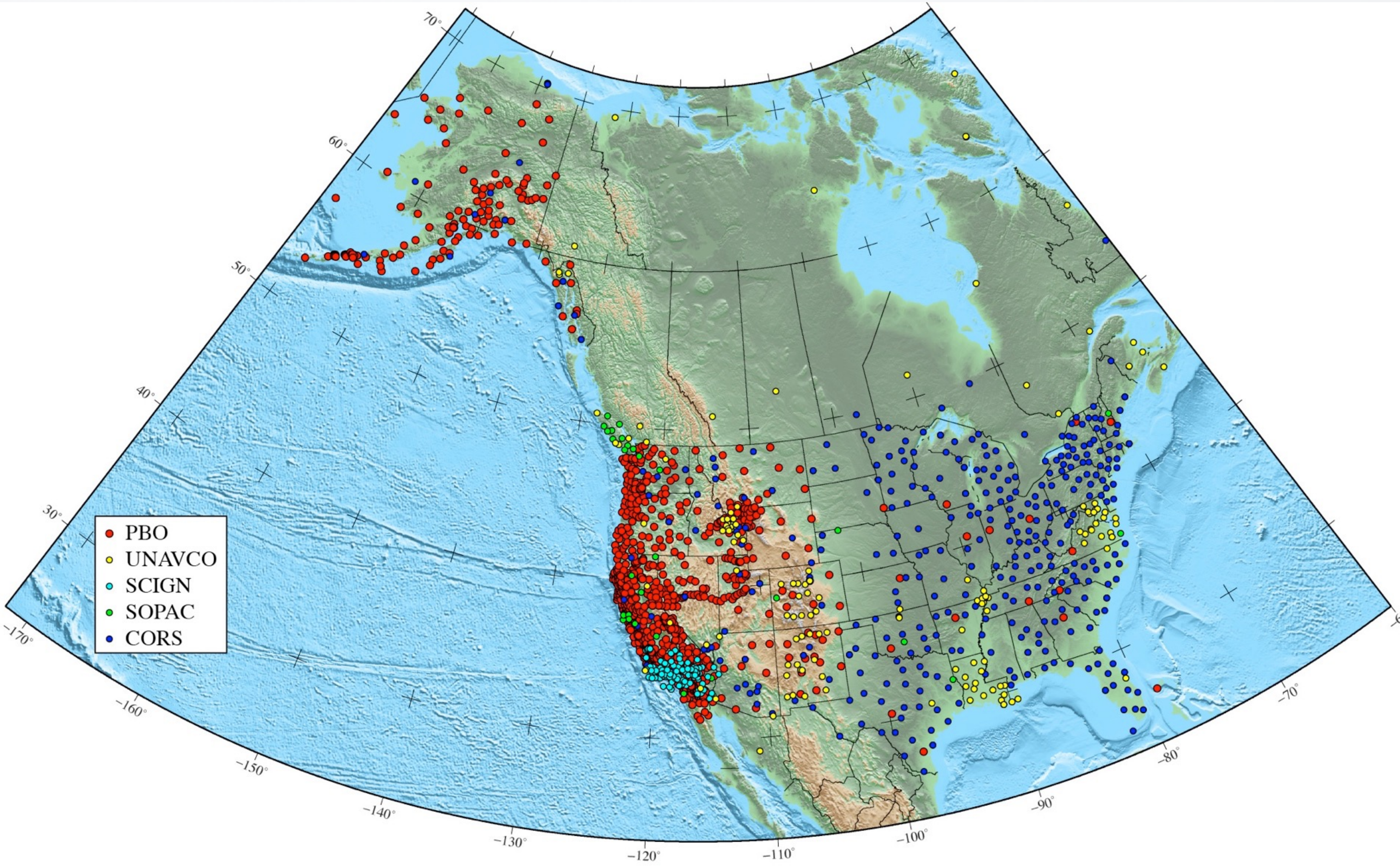
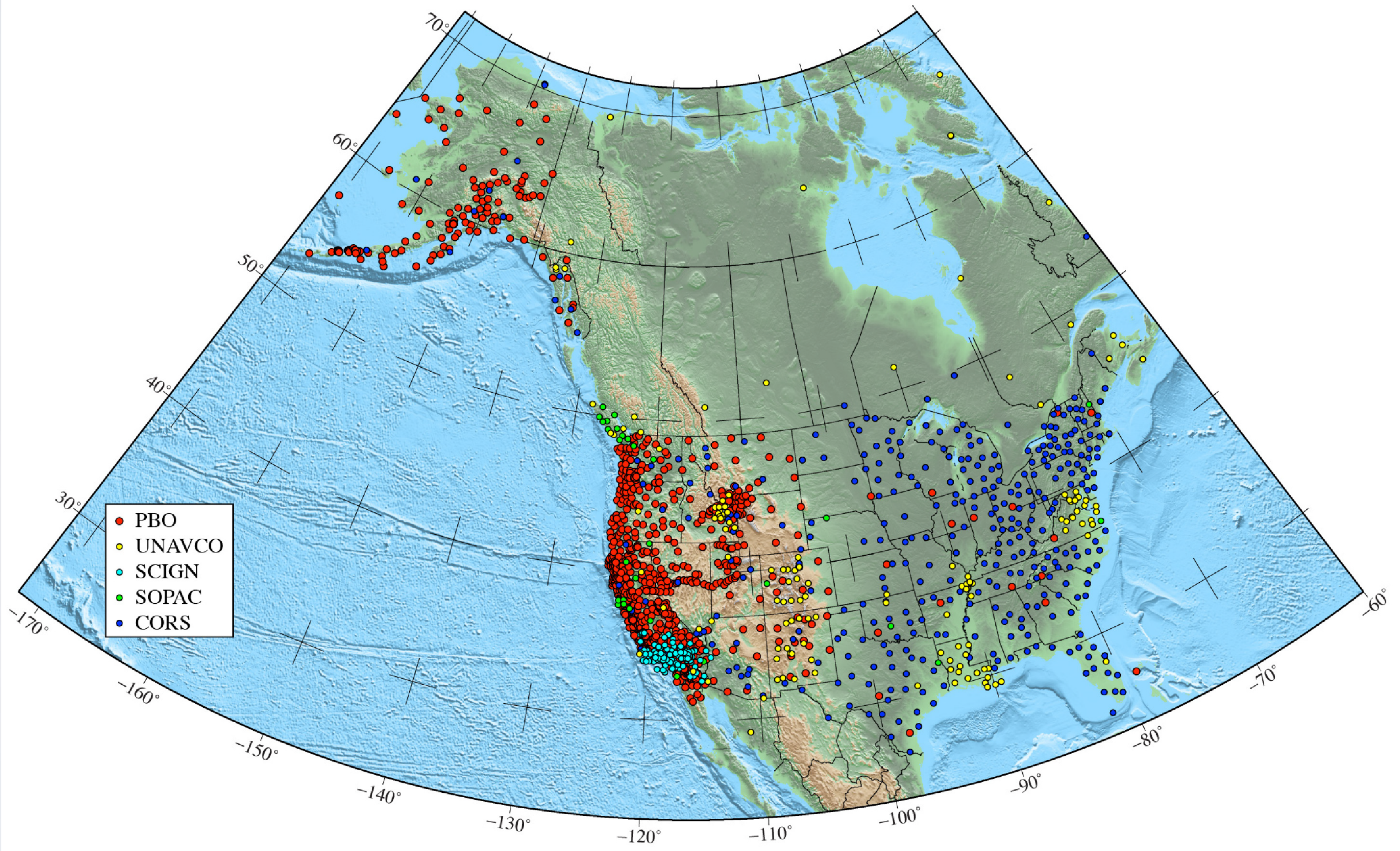
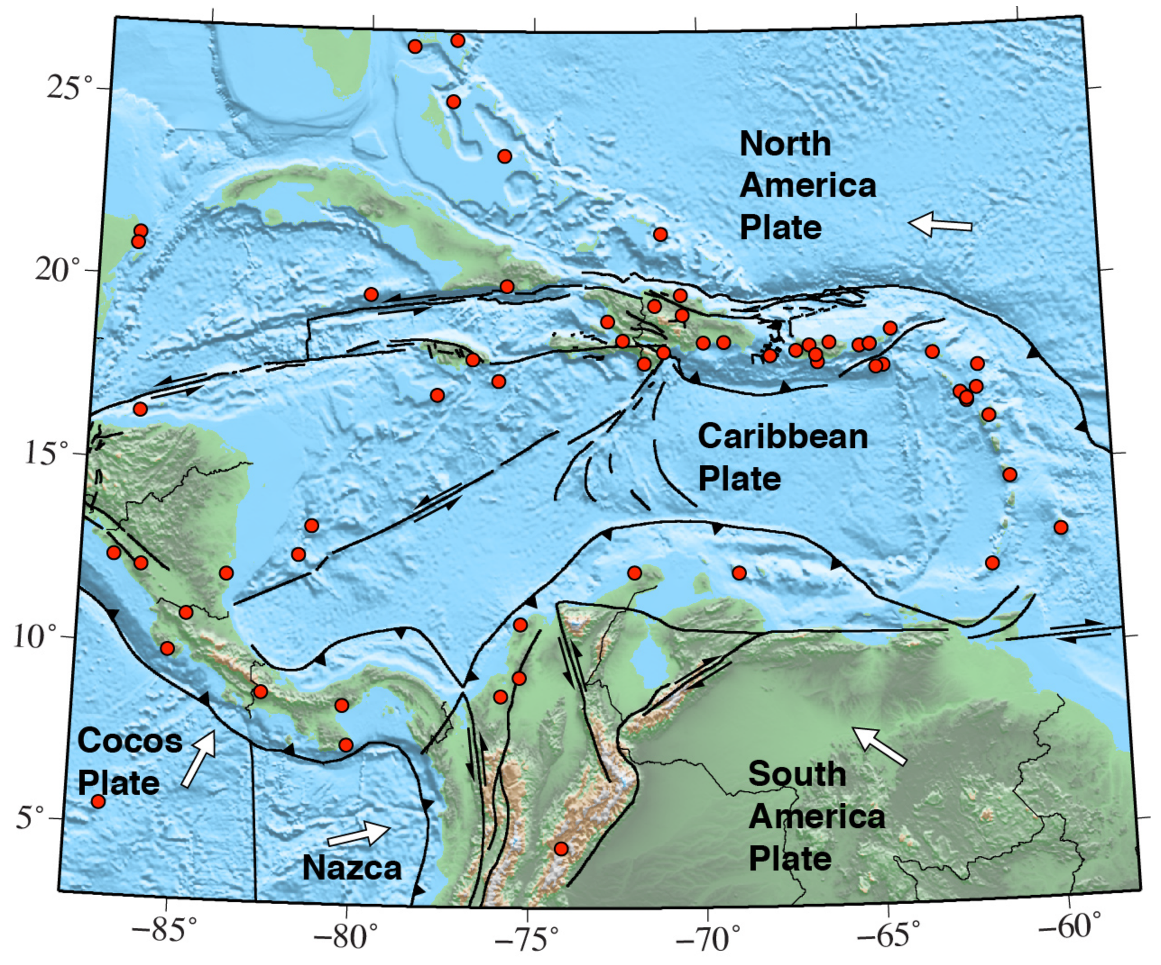


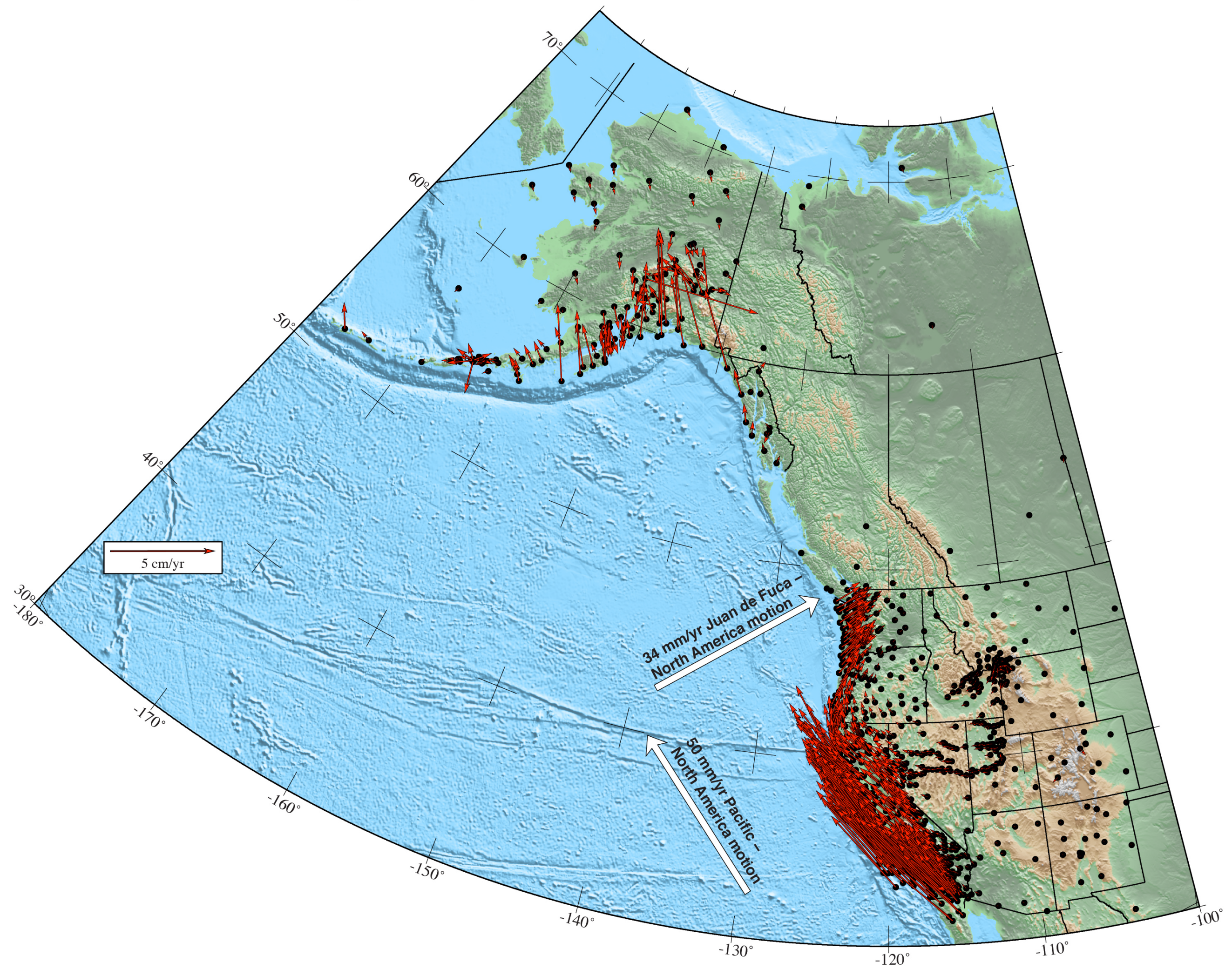
EXPANDED NETWORKS ANALYSIS

- PBO network data analysis expanding by 500+ stations in eastern US
- COCONet in Caribbean
- TLALOCNet in Mexico





- Processed GPS data
  - Time series
  - Velocities
  - SINEX files
  - Earthquake offsets
  - Metadata



- NAM08 successor to SNARF
  - Based on IGS08 reference frame
  - No glacial isostatic adjustments

GPS STATIONS - SIGNALS AND DATA QUALITY

Total GPS station apparent deformation is the sum of many contributing factors including:

- Regional tectonic deformation
- Local site geology
- Co-seismic offsets
- Post-seismic viscoelastic relaxation
- Volcanic inflation/deflation
- Glacial isostatic adjustment
- Ocean and atmospheric loading
- Continental water (surface, ground)
- Seasonal snow and ice (hydrologic loading)
- Equipment changes, damage or failure
- Antenna phase center errors
- Metadata errors
- Monument instability
- Anthropogenic processes such as ground water pumping or water storage in reservoirs

GPS Station Data Quality Assessment
(prepared by Christine Puskas)

Evaluating GPS Station Quality

Multiple methods for assessing quality and health at a station:

- Preprocessing (TEQC)
  - Signal-to-noise ratio
  - Multipath
- Post-processing quality parameters
  - Produced by University of Nevada-Reno
  - Hosted at UNAVCO
- GAGE Analysis Center internal quality checks
  - Random walk noise
  - Processing statistics (RMS, elevation angle noise)
- Visual inspection of time series

Note: Station Health != Station Quality

Station health: operation of equipment, telemetry

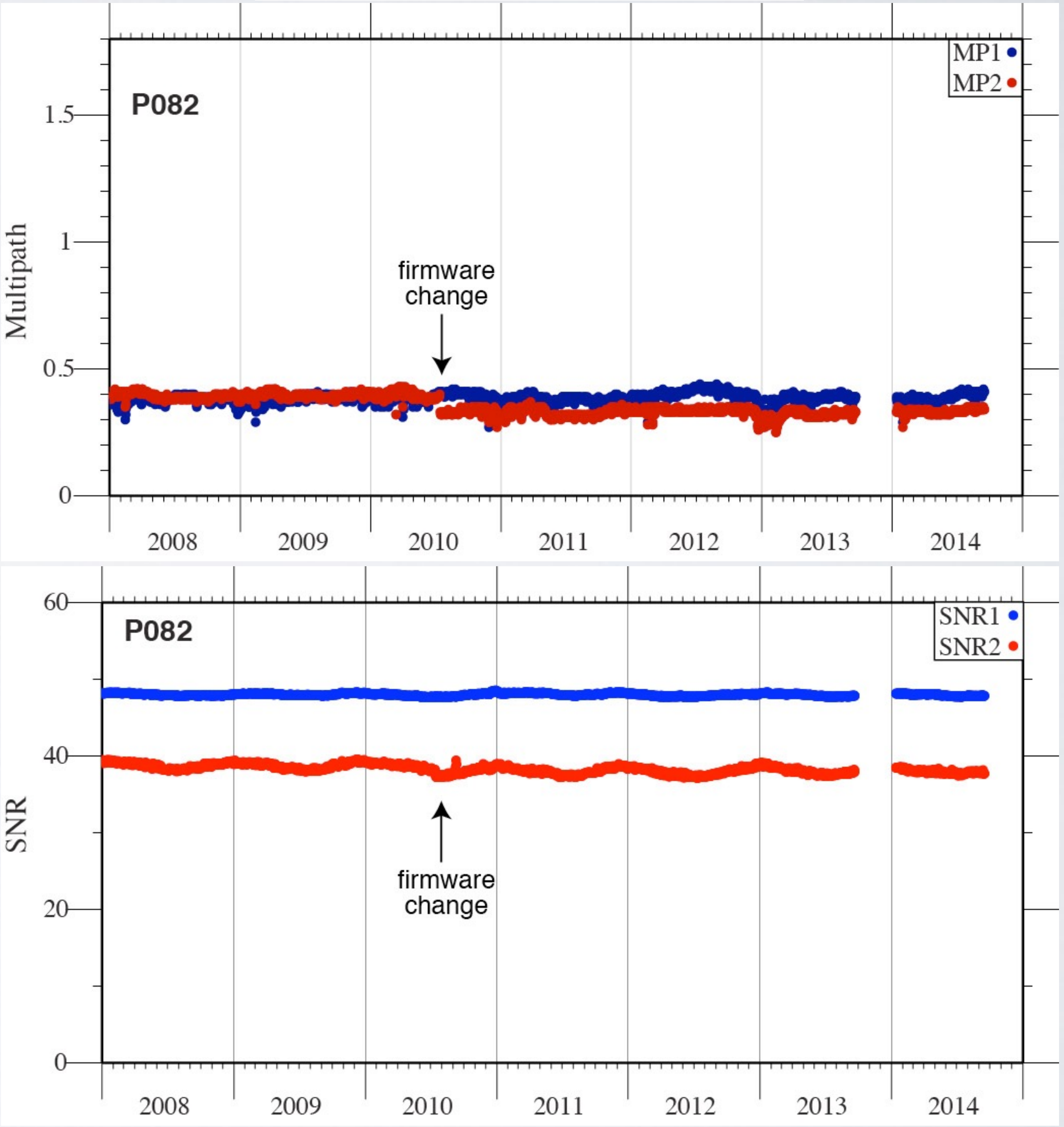
Station quality: standards to evaluate "goodness" of station position solutions

Evaluating GPS Station Quality

TEQC

- Daily QC files at ftp://data-out.unavco.org/pub/rinex/qc
- Plots at station home pages/station health tab
- Signal-to-Noise (SNR)
  - Measure signal strength
  - Values usually depend on instrument health
- Multipath
  - Measure reflected signals
  - Values depend on antenna type, local environment
- Use to assess state of health and environment

L1 & L2 Multipath and Signal-to-Noise

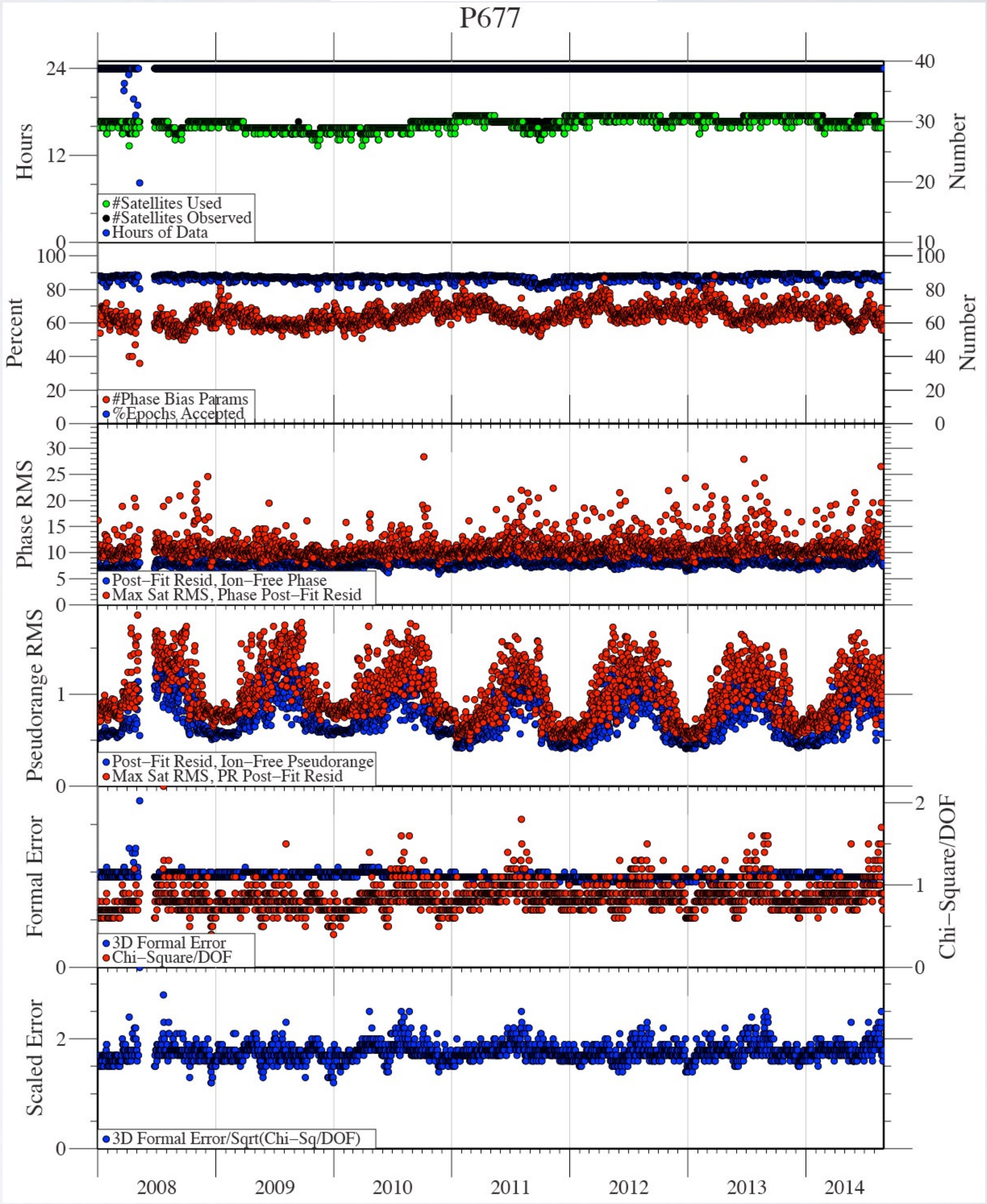


Evaluating GPS Station Quality

UNR quality assurance parameters

- Produced by UNR GPS processing
  - NASA-funded product that includes PBO network data and is archived at UNAVCO
  - Several parameters derived during processing
  - RMS values, formal errors, chi-square
- Daily QA files at ftp://data-out.unavco.org/pub/products/unr_qa
- CSV files to be plotted by user
  - by site: time history for each station
  - by date: snapshot for all stations on given date
- Reflect station health, quality

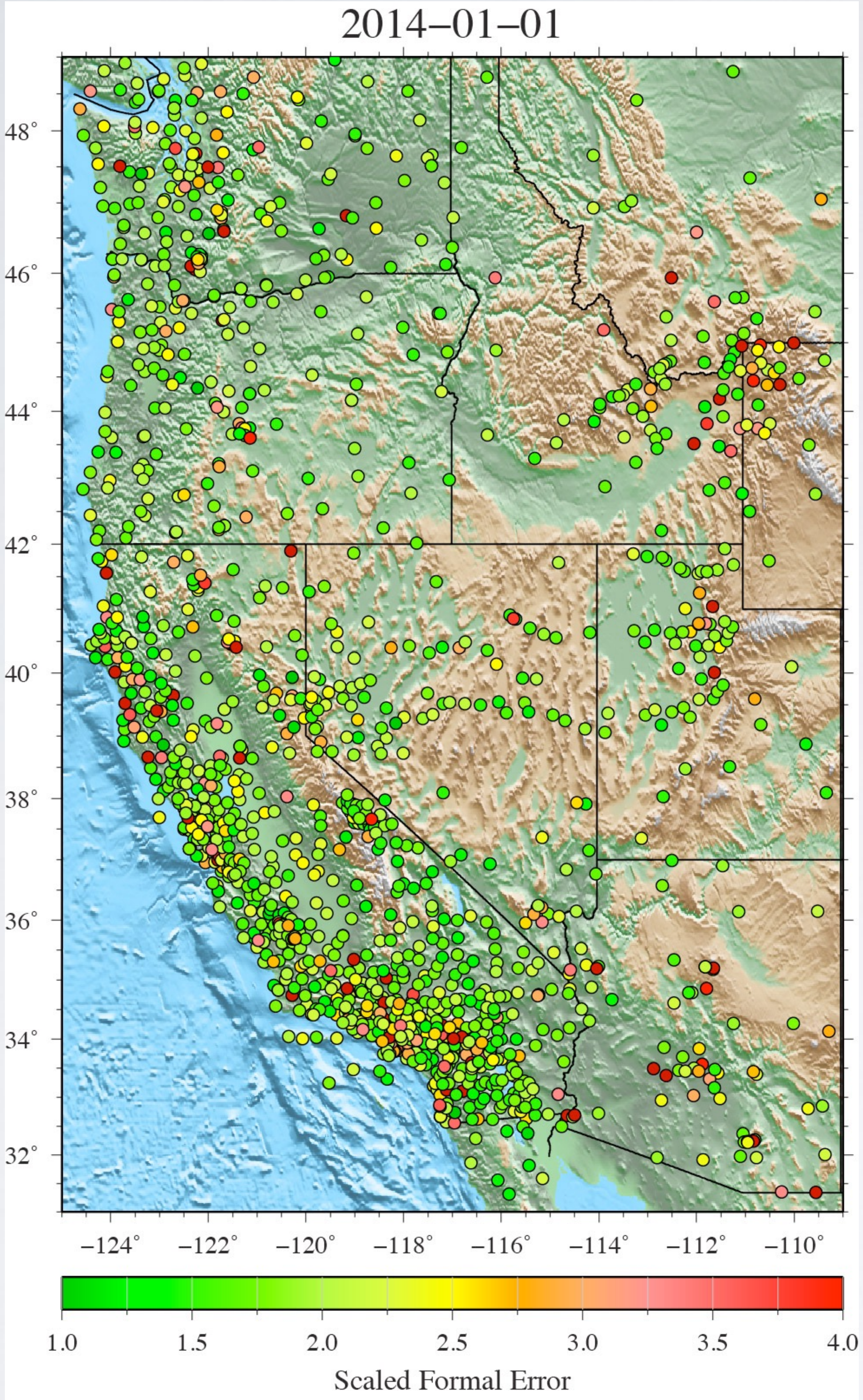
Quality Parameters

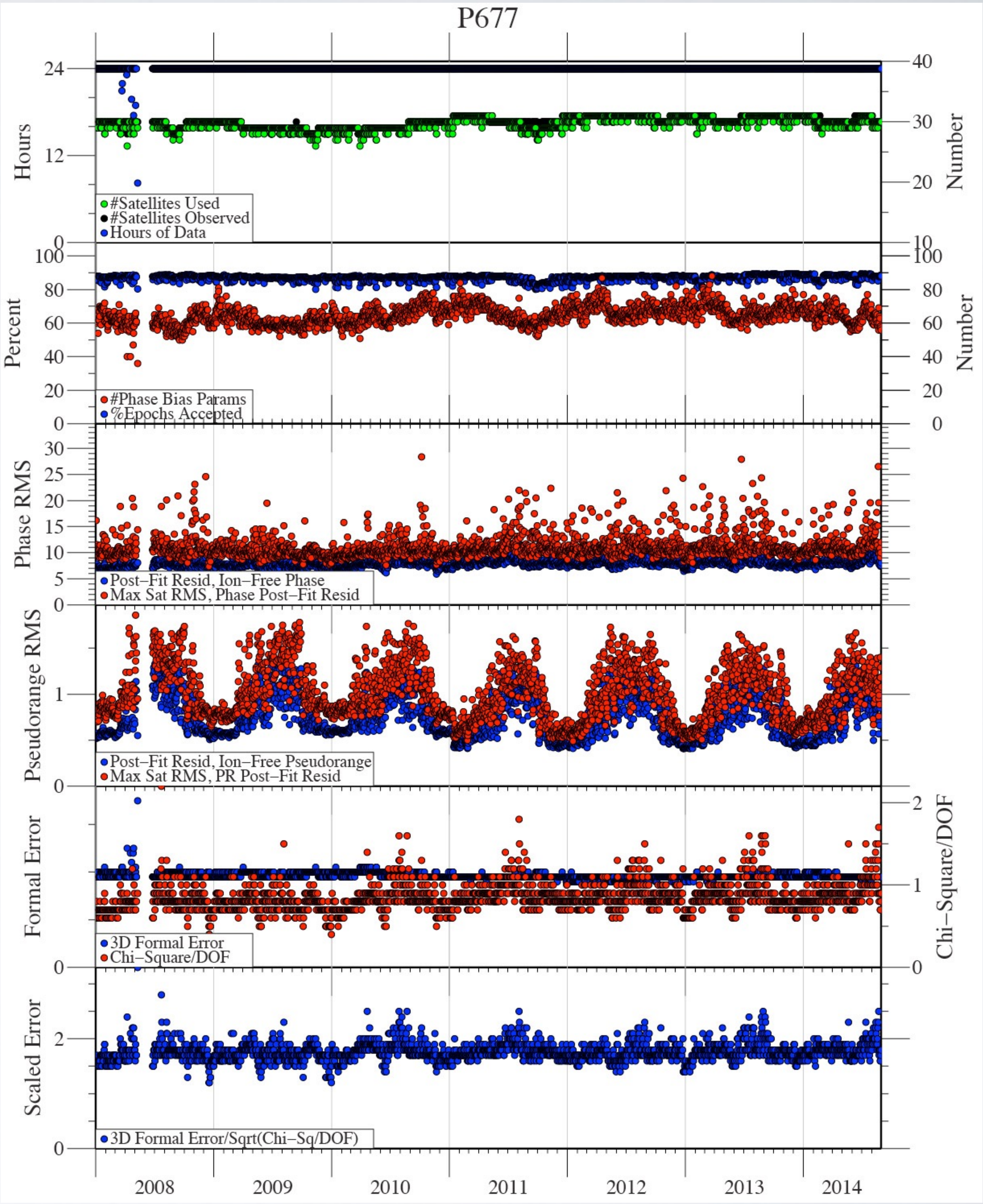


UNR GPS Data QA.

1. Map view of scaled error of PBO stations.

2. Larger view of QA time series for P677.



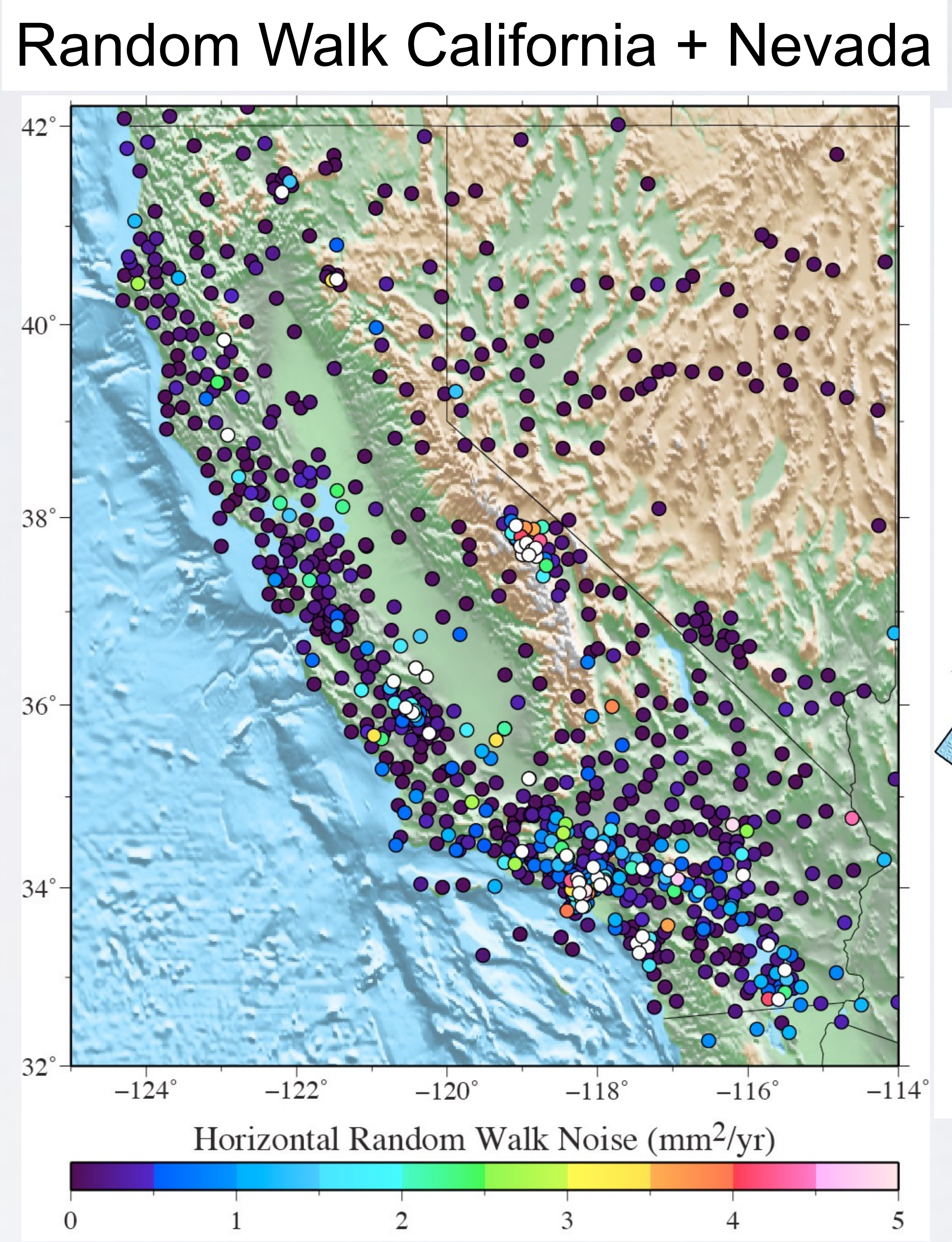


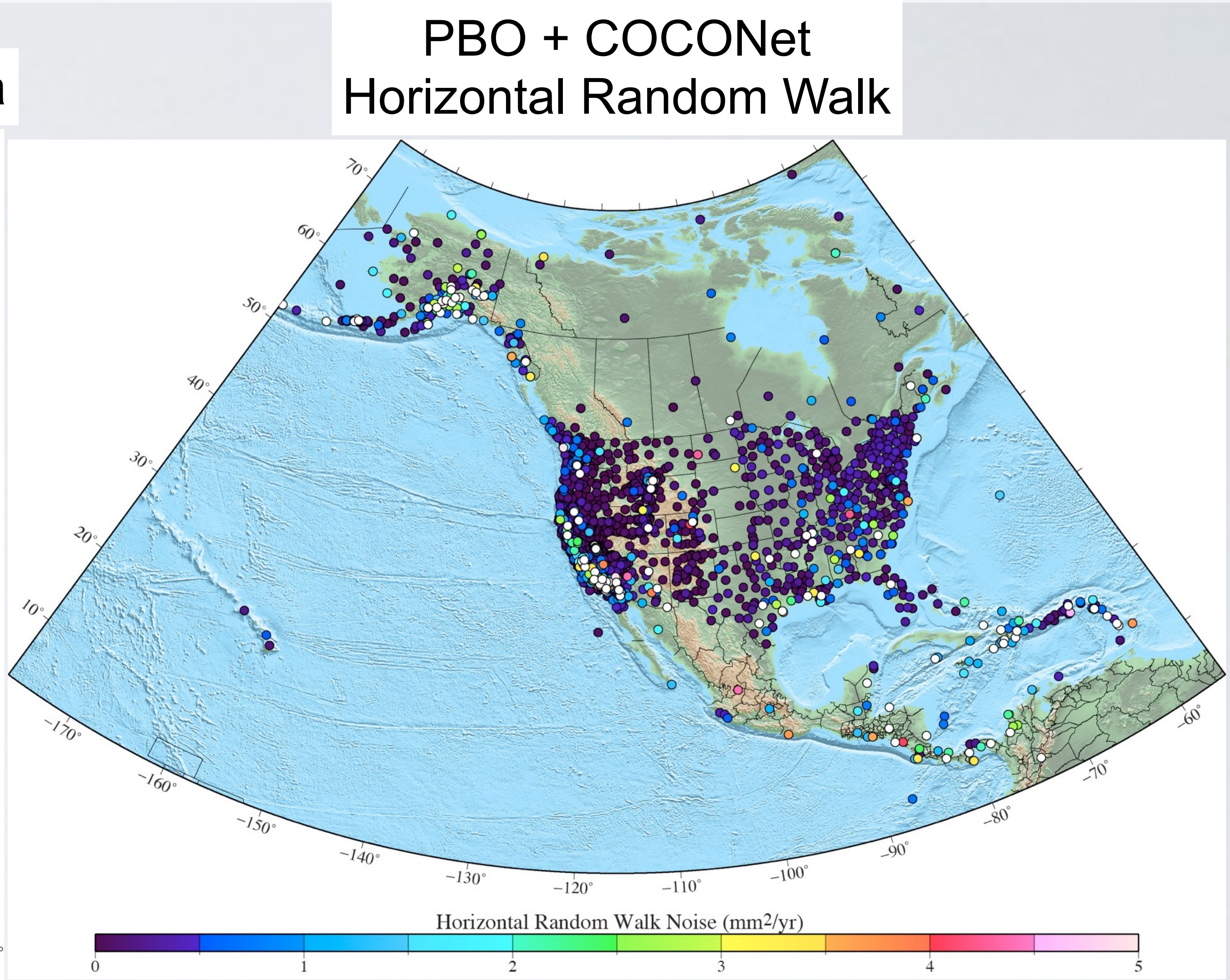
Evaluating GPS Station Quality

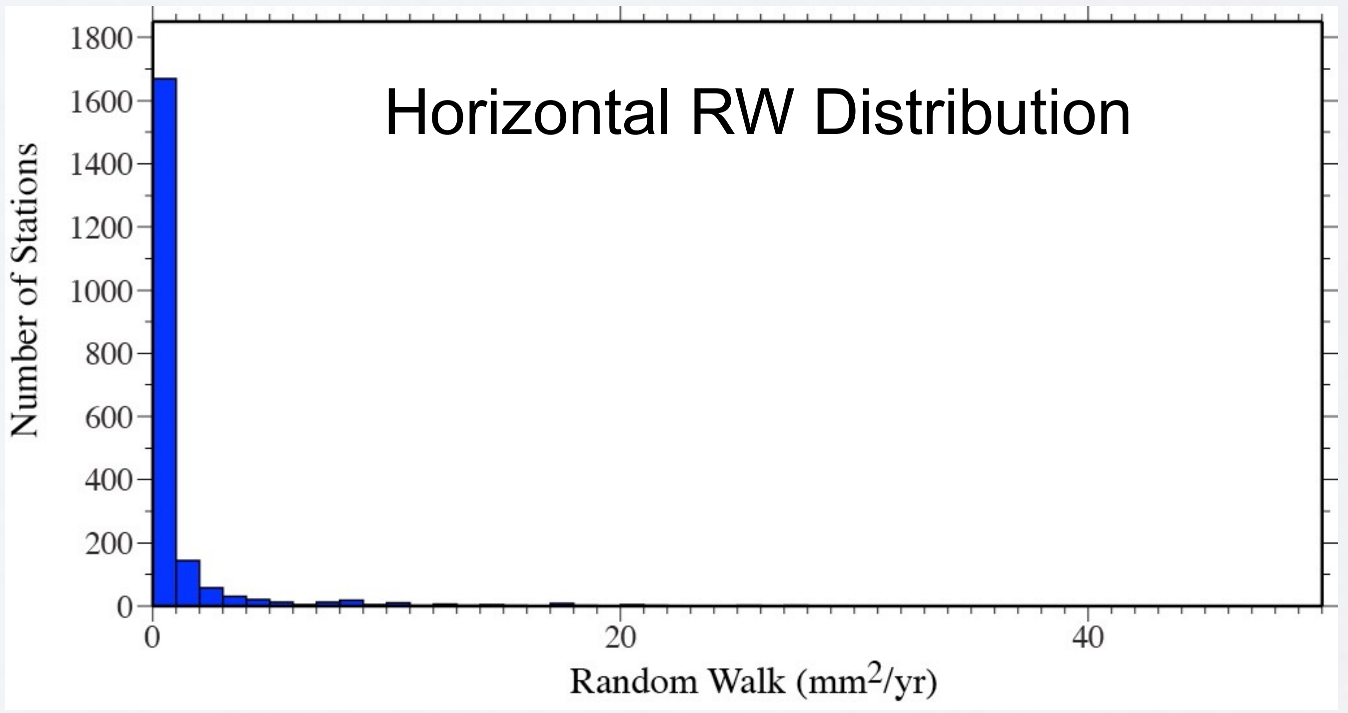
AC quality checks

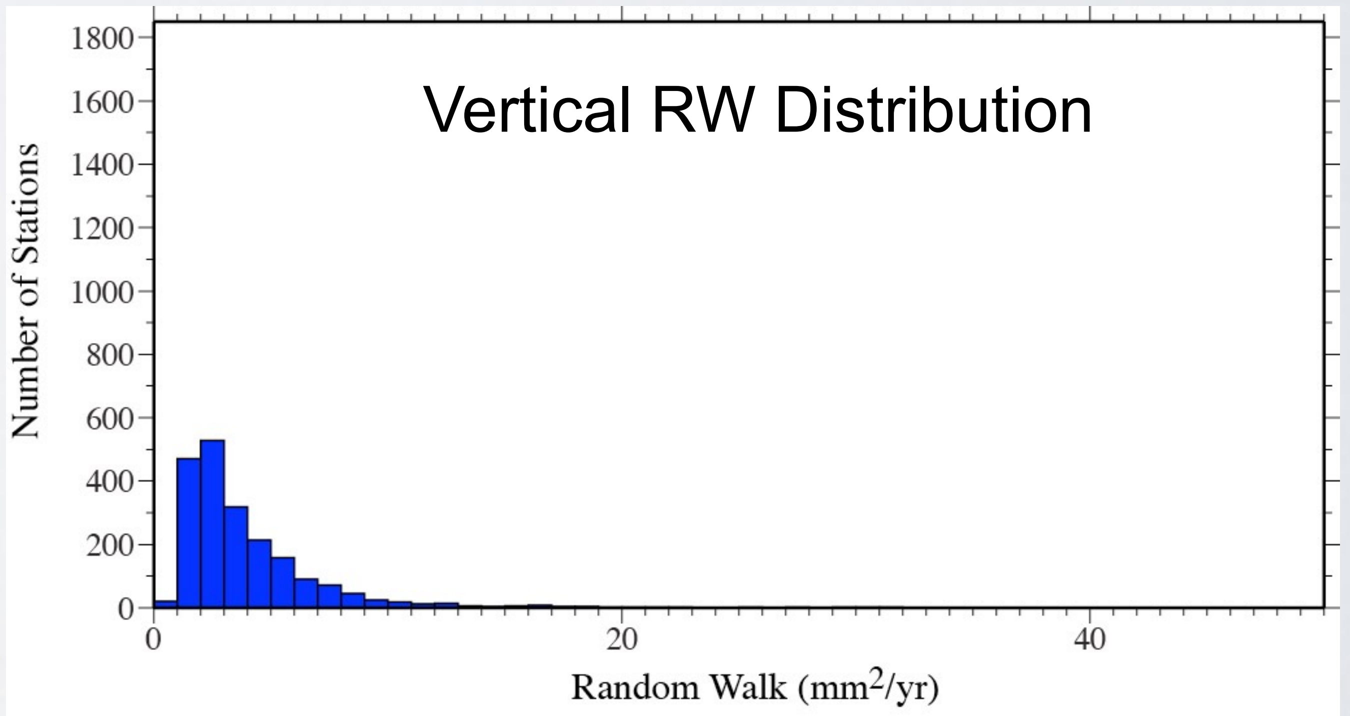
- Processing statistics available through SINEX files at UNAVCO ftp archives: ftp://data-out.unavco.org/pub/products/sinex

- Time series analysis - random walk noise
  - To be published soon with analysis methods (will be available from UNAVCO web site)
  - Numeric values to describe NEU components
  - Account for station offsets, post-seismic decay







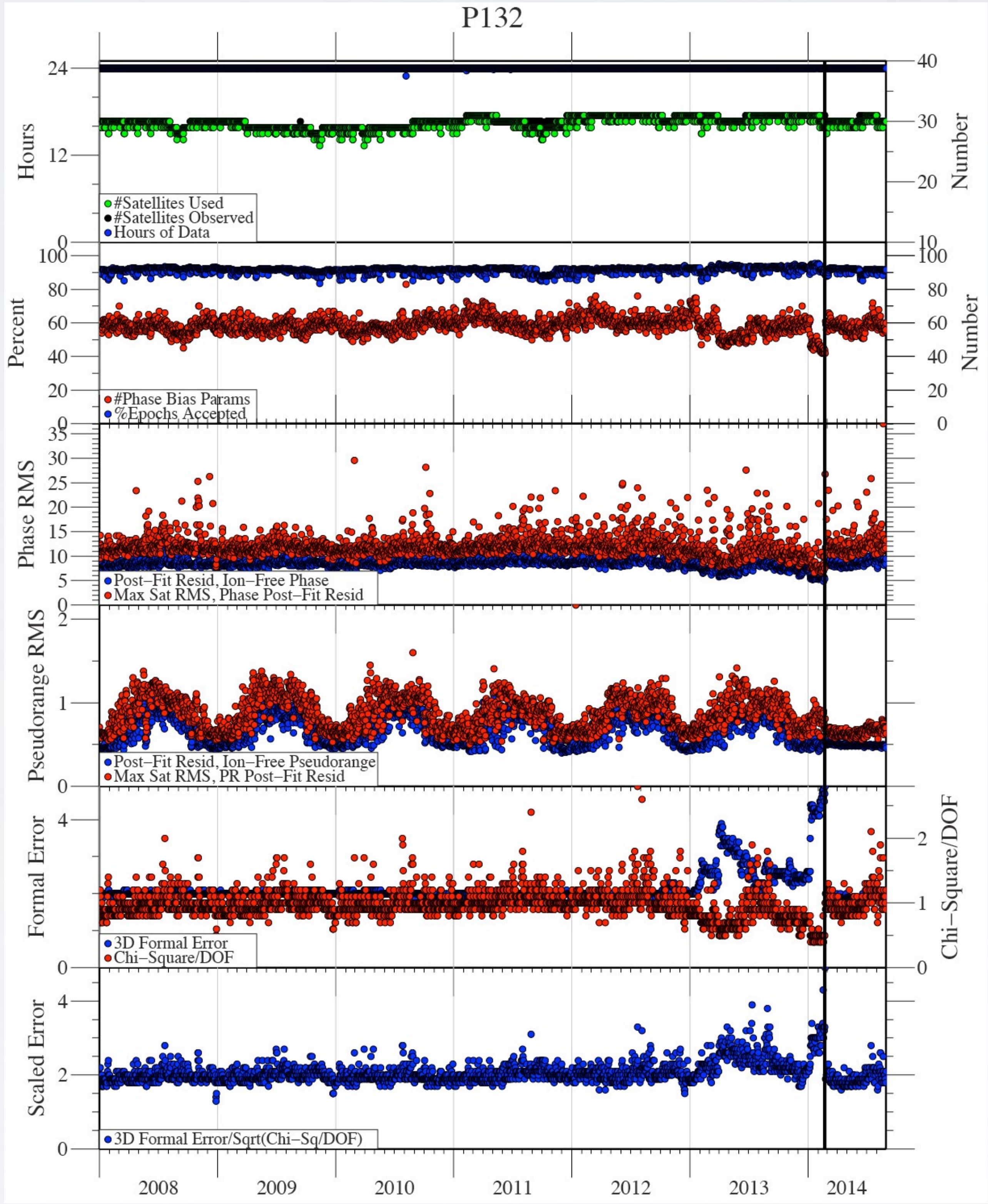


Evaluating GPS Station Quality

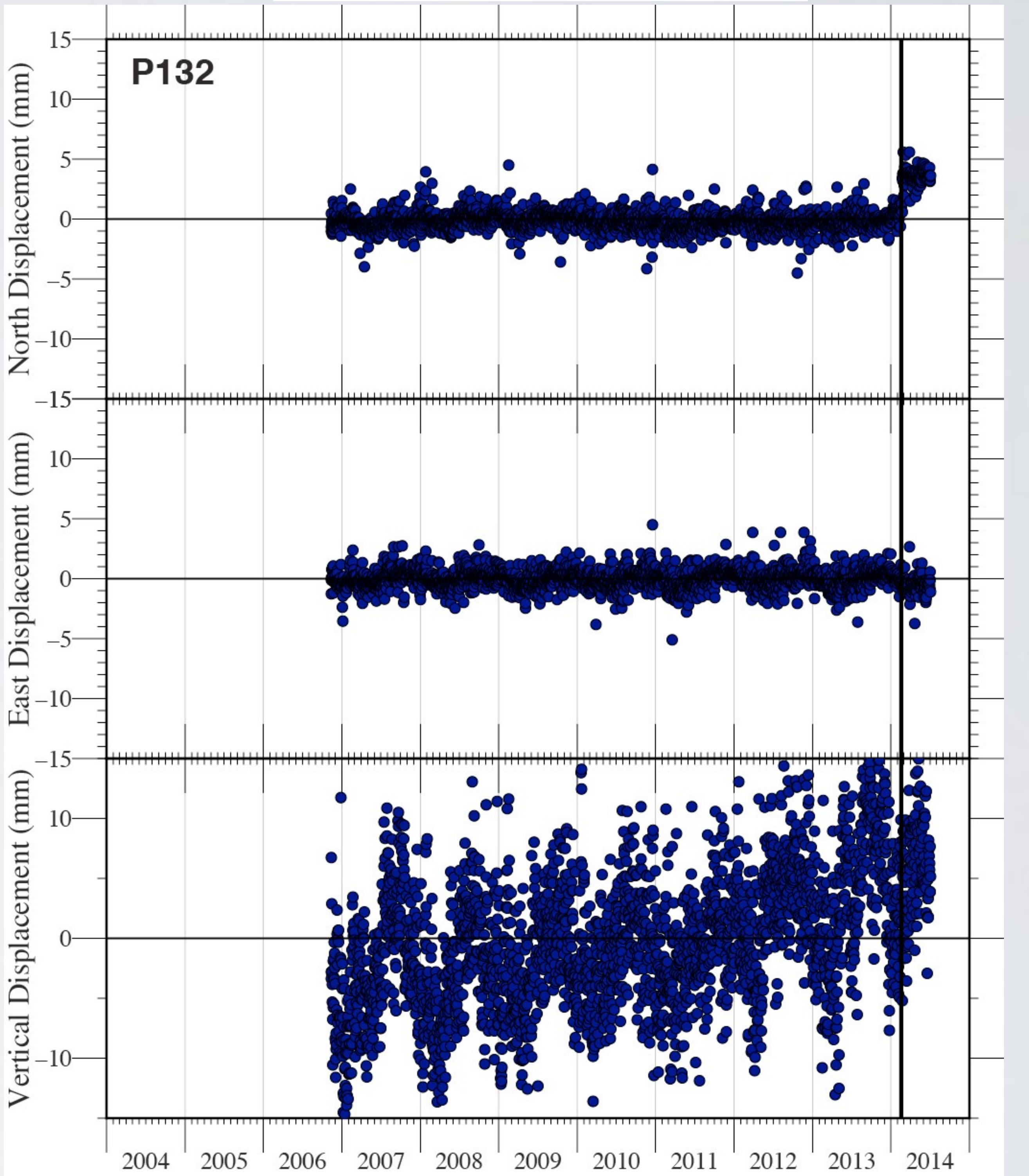
Example: P132

- Horizontal RW = 0.004 (one of the best)
- Station history
  - Antenna change in February 2014
  - Receiver firmware change in February 2011

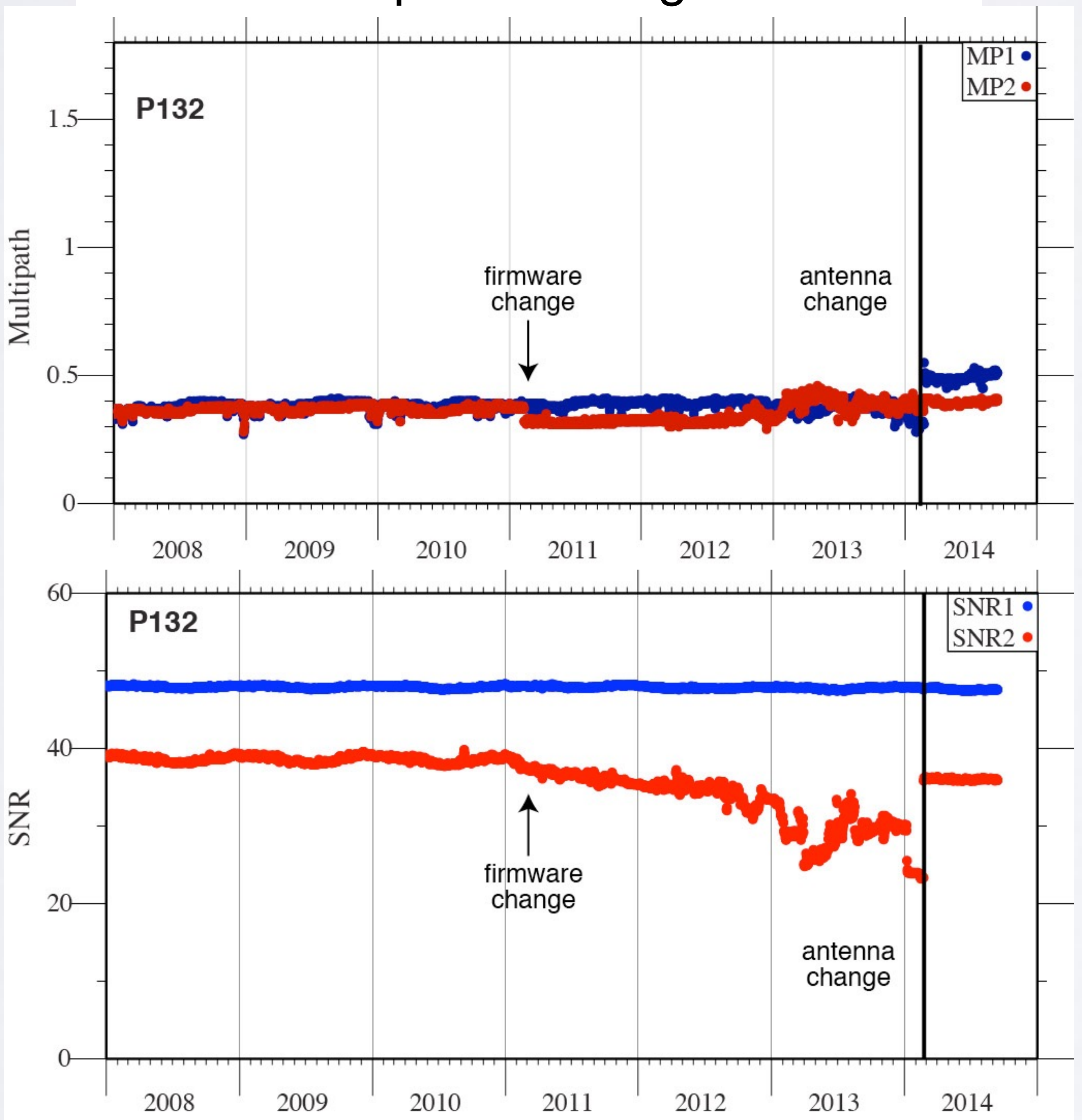
Quality Parameters

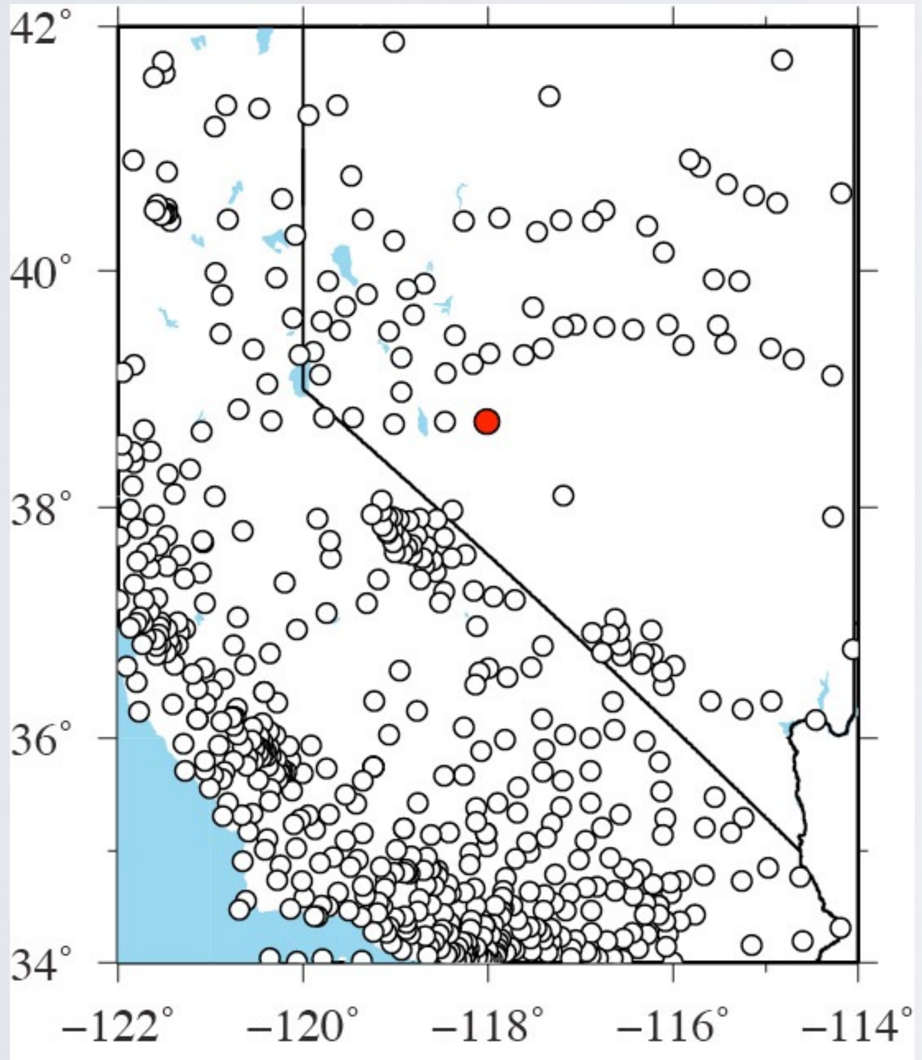


Detrended Time Series



L1 & L2 Multipath and Signal-to-Noise



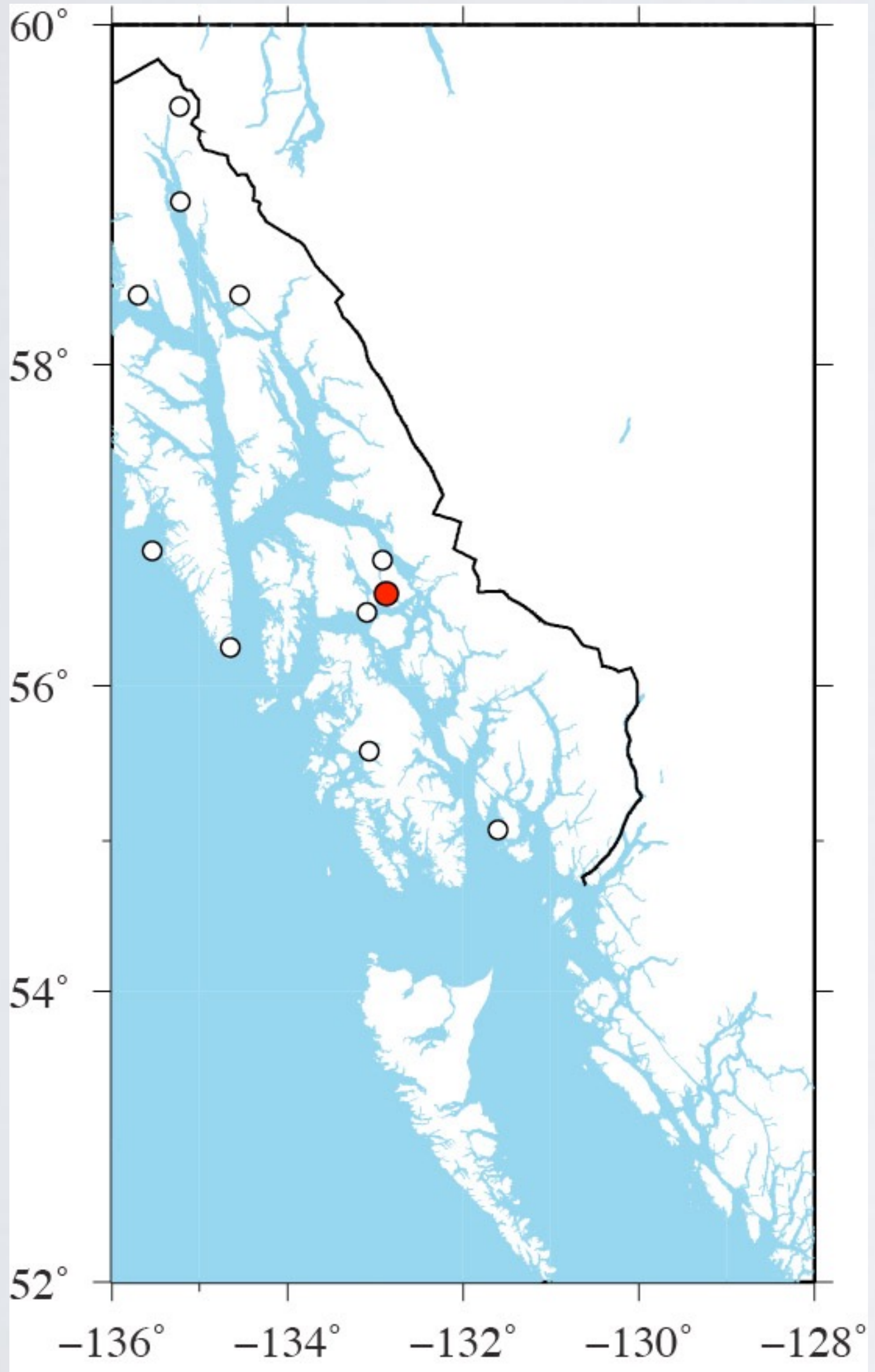


- Antenna problems affect SNR and QA parameters but do not affect time series
- Antenna replacement produces time series offset

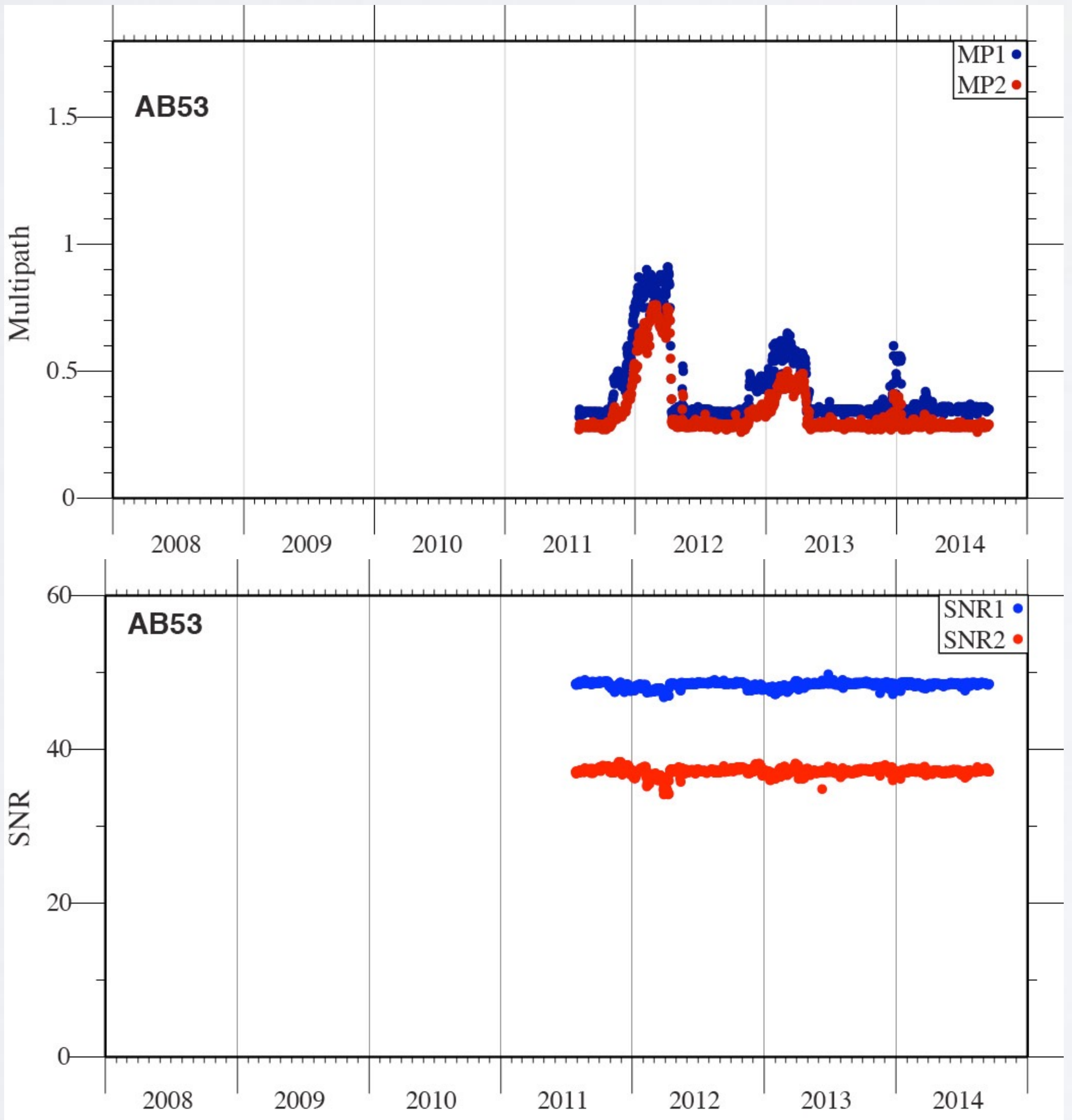
Evaluating GPS Station Quality

Example: AB53

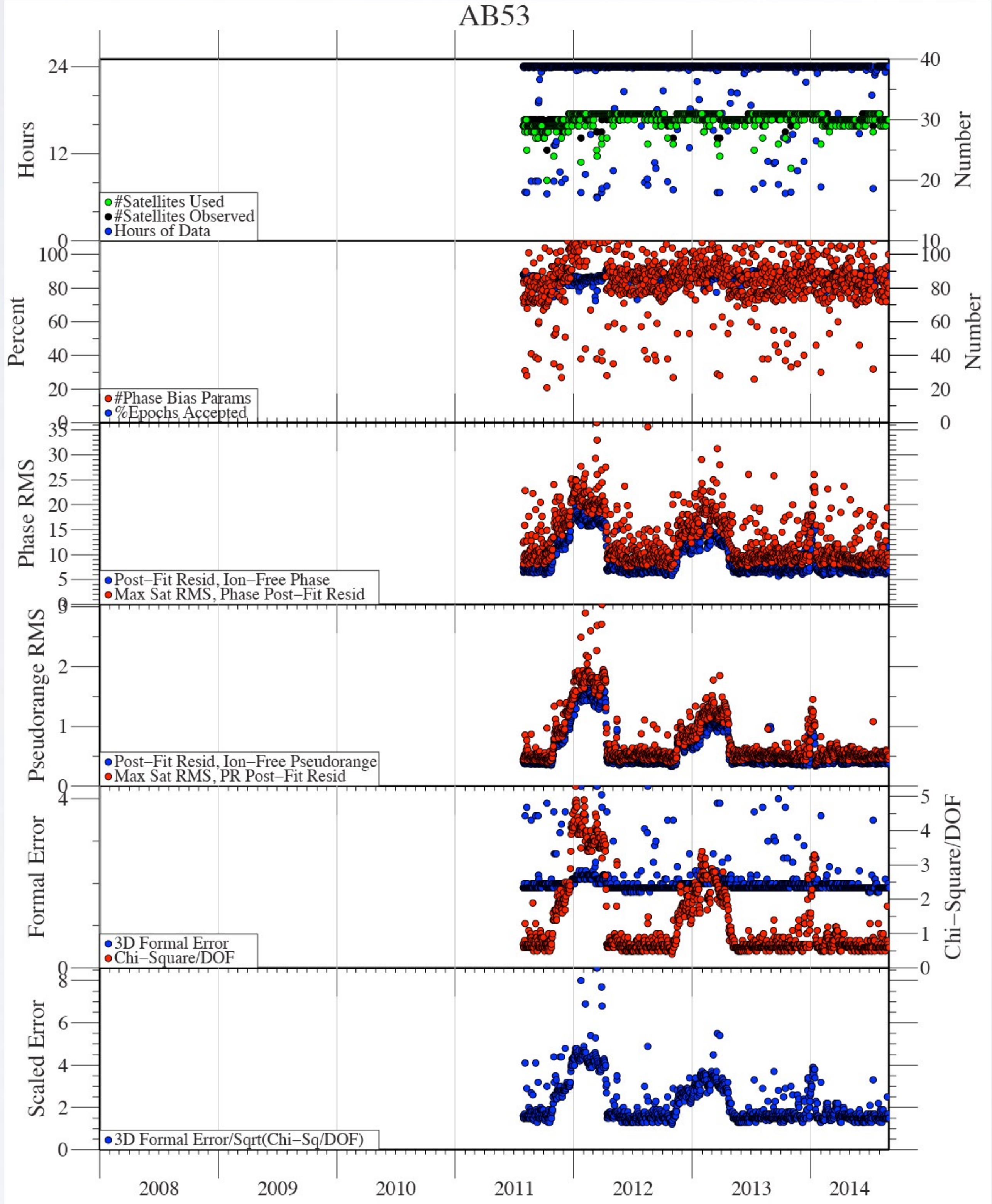
- Horizontal RW = 52.288 (bad)
- Station history
  - Offset by Jan 5, 2013 M7.5 Craig earthquake



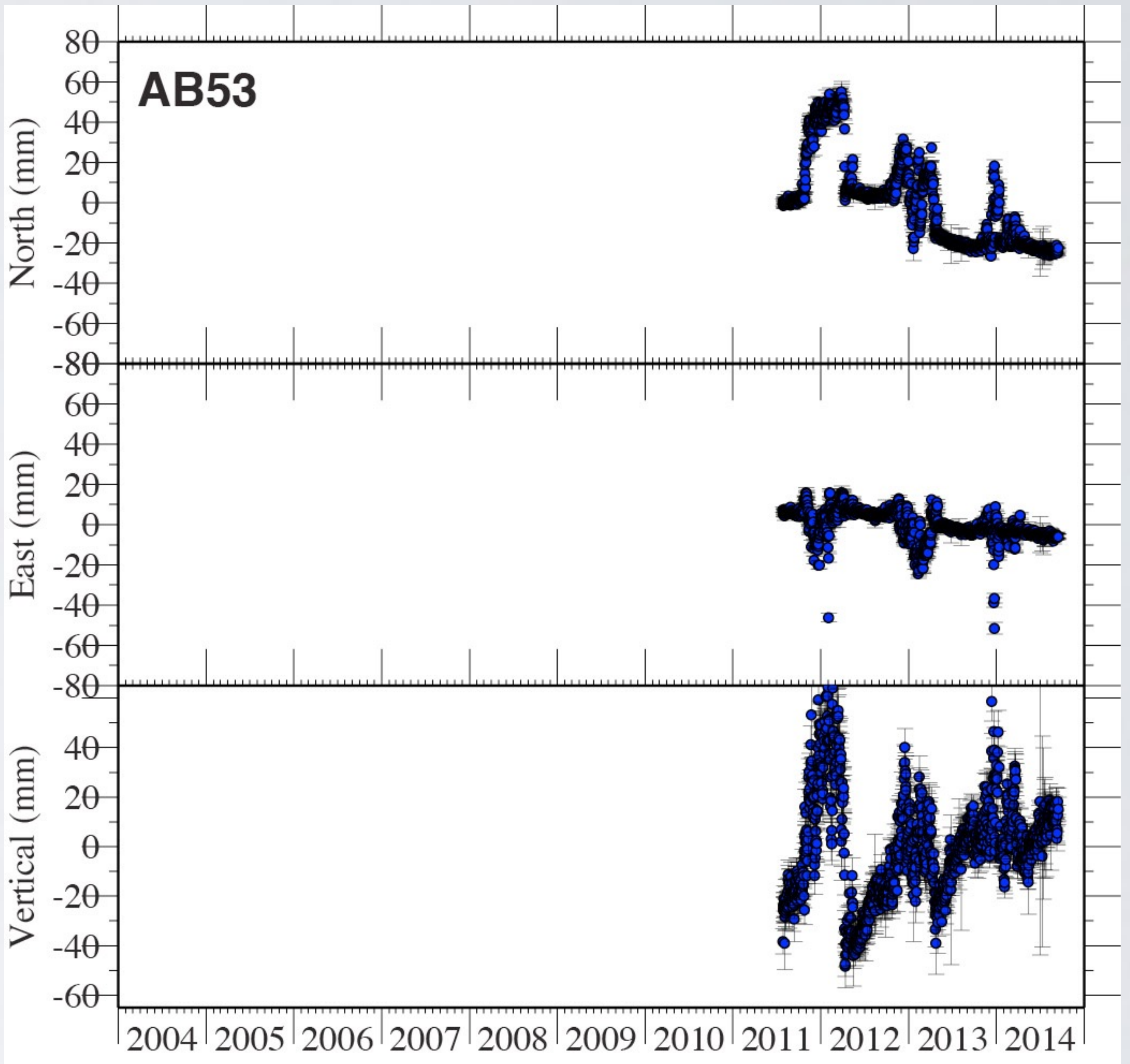
L1 & L2 Multipath and Signal-to-Noise



Quality Parameters



Time Series

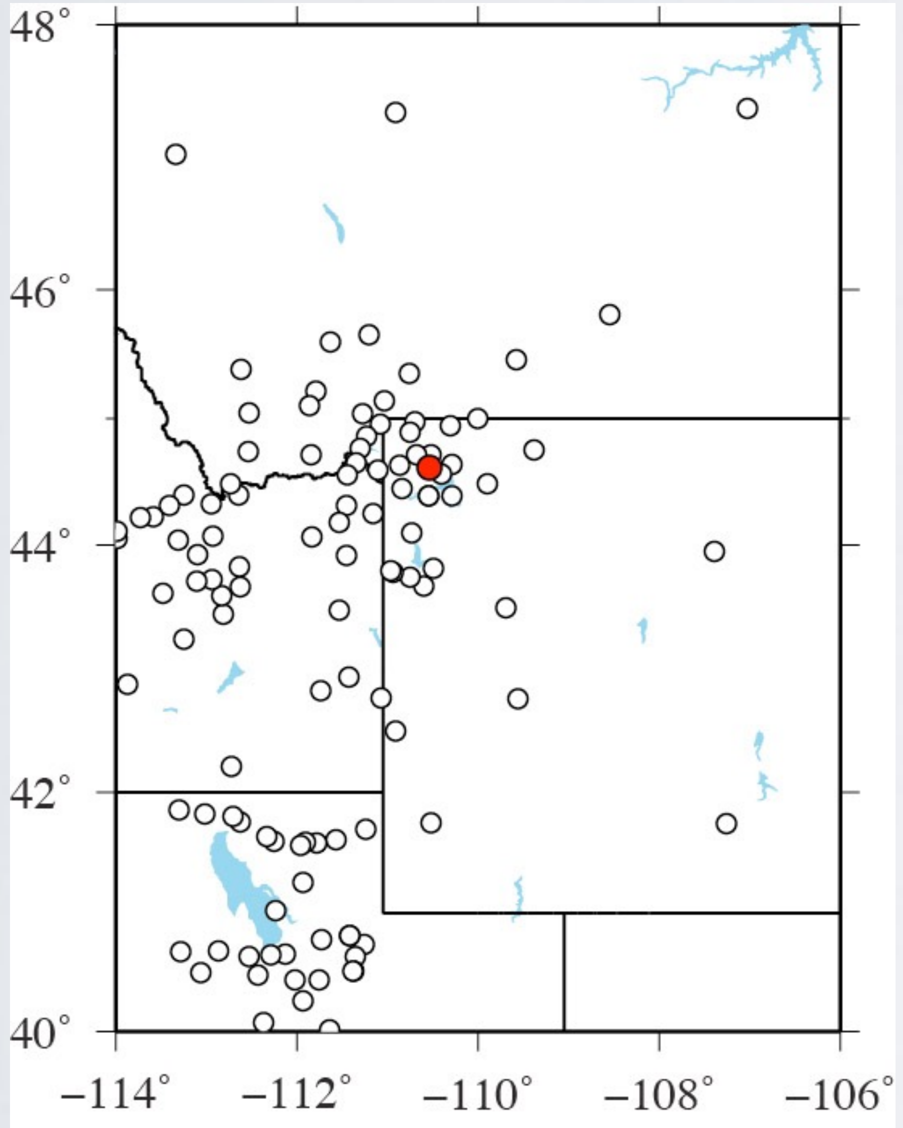


Snow causes spikes in time series, MP, QA parameters

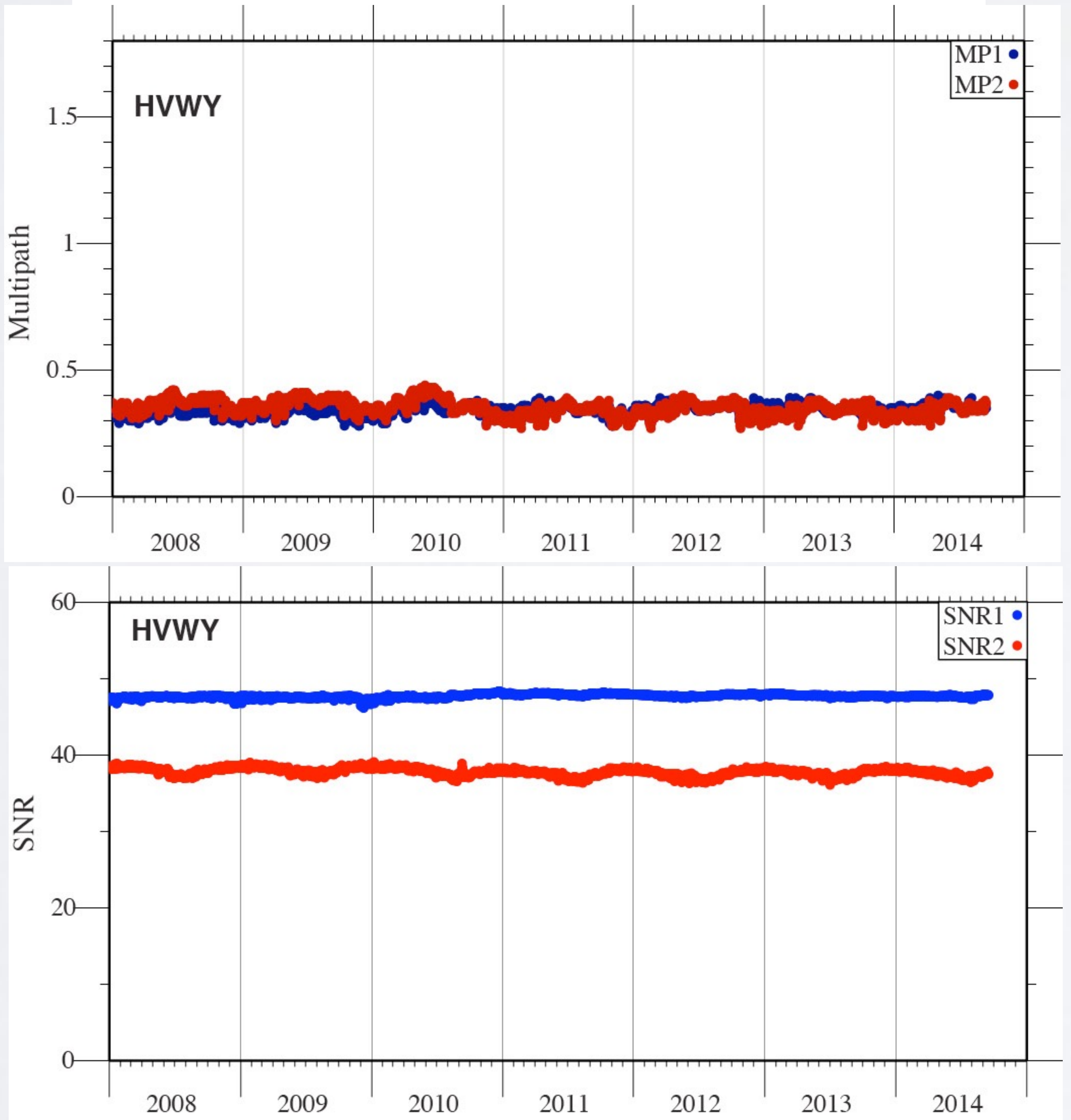
Evaluating GPS Station Quality

Example: HVWY

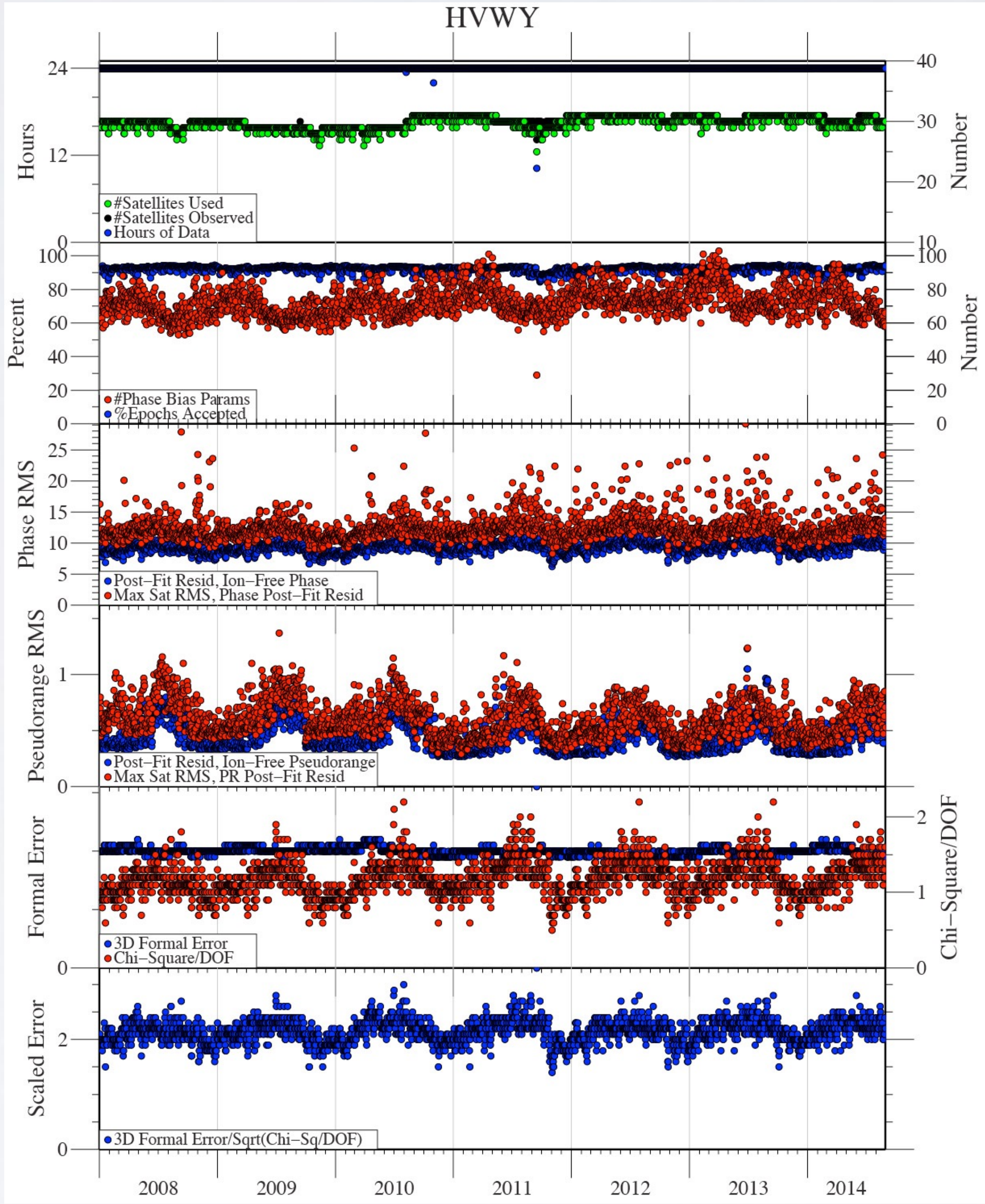
- Horizontal RW = 51.864 (bad)
- Station history
  - Receiver change September 2006
  - Yellowstone Lake swarm Dec 2008-Jan 2009



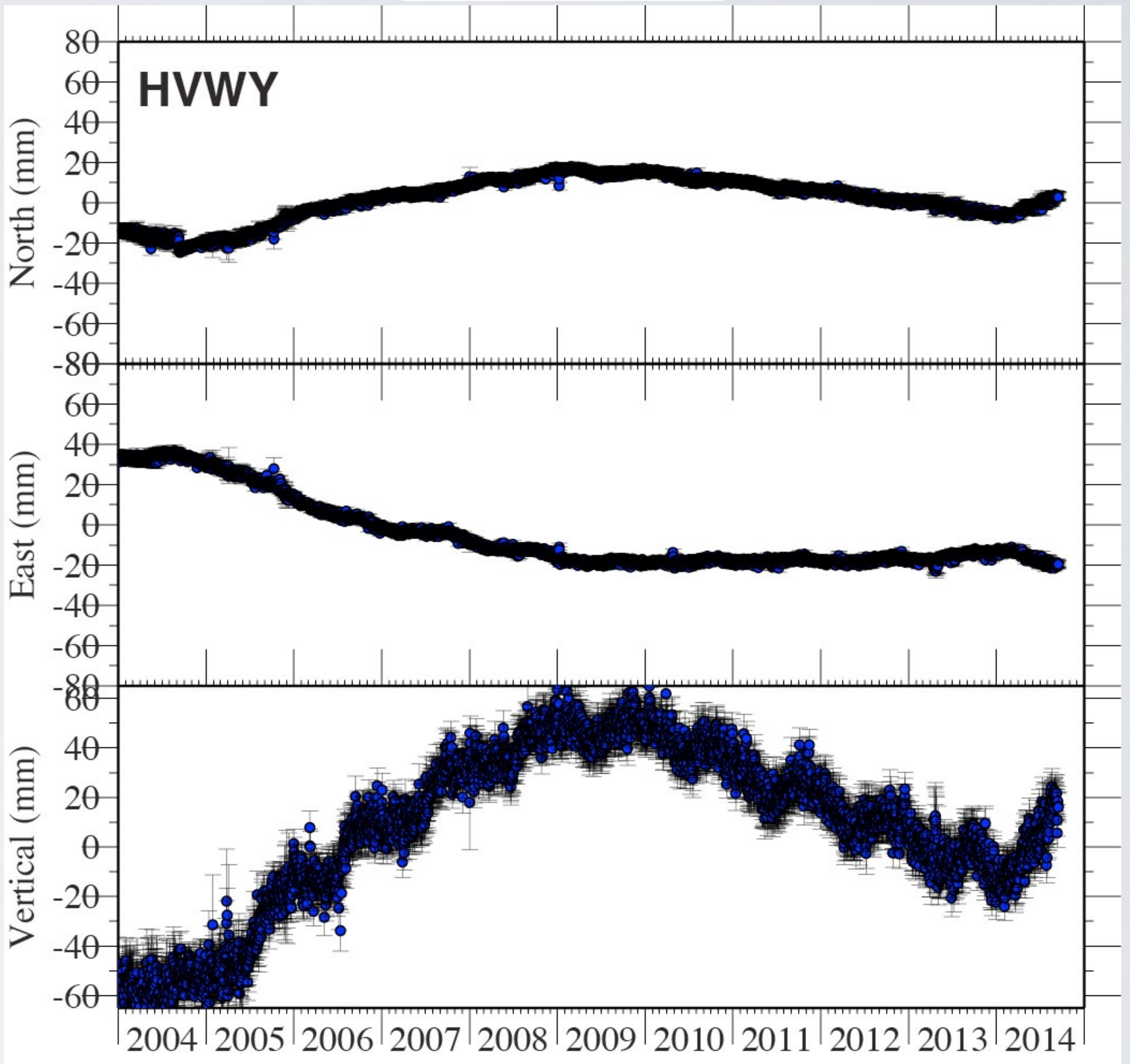
L1 & L2 Multipath and Signal-to-Noise



Quality Parameters



Time Series



Volcanic station in Yellowstone caldera
Measured ~12 cm uplift from 2004-2010, followed by subsidence, then uplift again
Nonlinear deformation

Evaluating GPS Station Quality

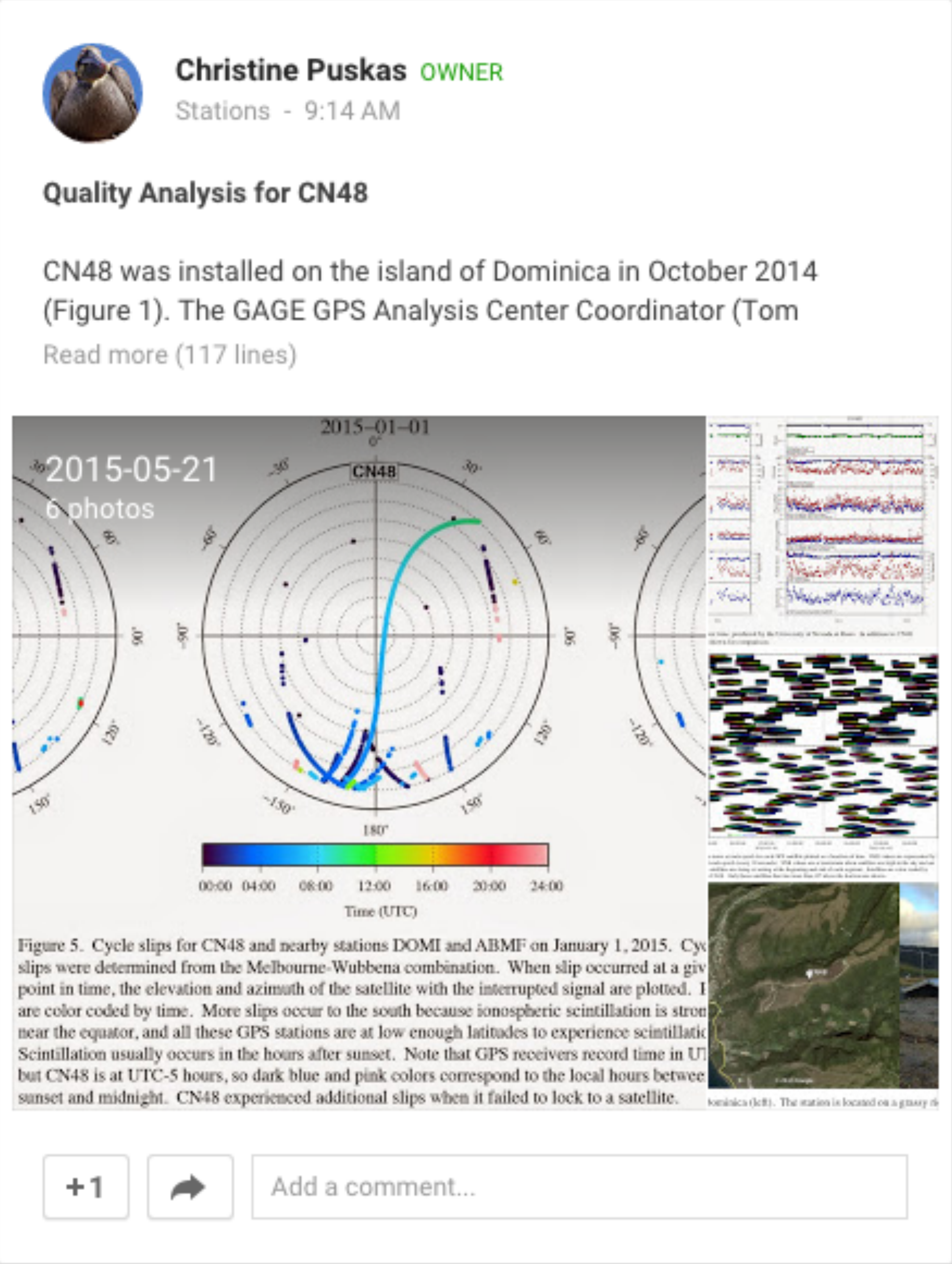
- Quality evaluation is complicated
- UNAVCO engineers, PBO Analysis centers, UNR each spend time and resources on quality assessments
- QA parameters, MP, SNR are starting points
  - Cross-check against time series
  - Cross-check against station maintenance history
  - Some familiarity with GPS processing
  - Knowledge of environmental factors (snowfall, groundwater pumping, volcanism, etc.)

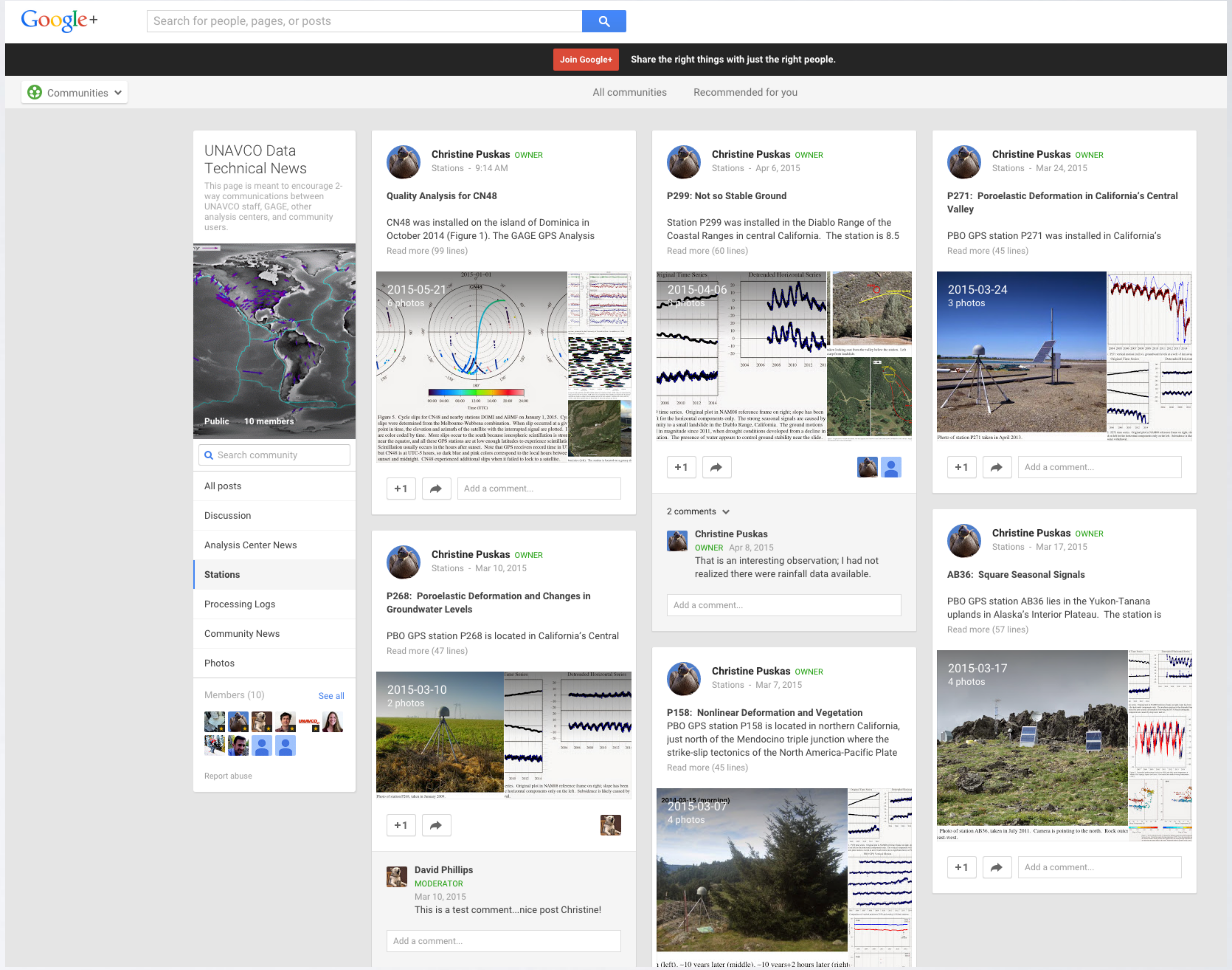
Wildfire Protection
WLWY, Yellowstone

Maintenance
AV27, Unimak Island

UNAVCO

STATION STORIES





FUTURE DIRECTIONS AND DRIVERS

Data Quality

Metadata
Improvements in tools for recording metadata in the field
Improved standards for metadata sharing
Better metadata obtained at the time it is needed

Preprocessing
QC for GNSS - solve this for the new signals, constellations

Processing and Post-processing
Big data
Complex station histories
More input from data users and processors