

Short Course

Plug and Play GPS for Earth Scientists:

Providing Immediate Access to Low-Latency Geodetic Products for Rapid Modeling and Analysis of Natural Hazards

Wednesday morning, January 20, 2016

AfricaArray workshop

University of the Witwatersrand

Johannesburg, South Africa

Instructor: Bill Hammond

whammond@unr.edu

for the Plug and Play team of

UNAVCO, Inc. and the University of Nevada, Reno

UNAVCO, Inc.
6350 Nautilus Drive
Boulder, CO 80301

Nevada Geodetic Laboratory
Nevada Bureau of Mines and Geology
University of Nevada, Reno
Reno NV, 89557



Instructor Introduction: About Bill

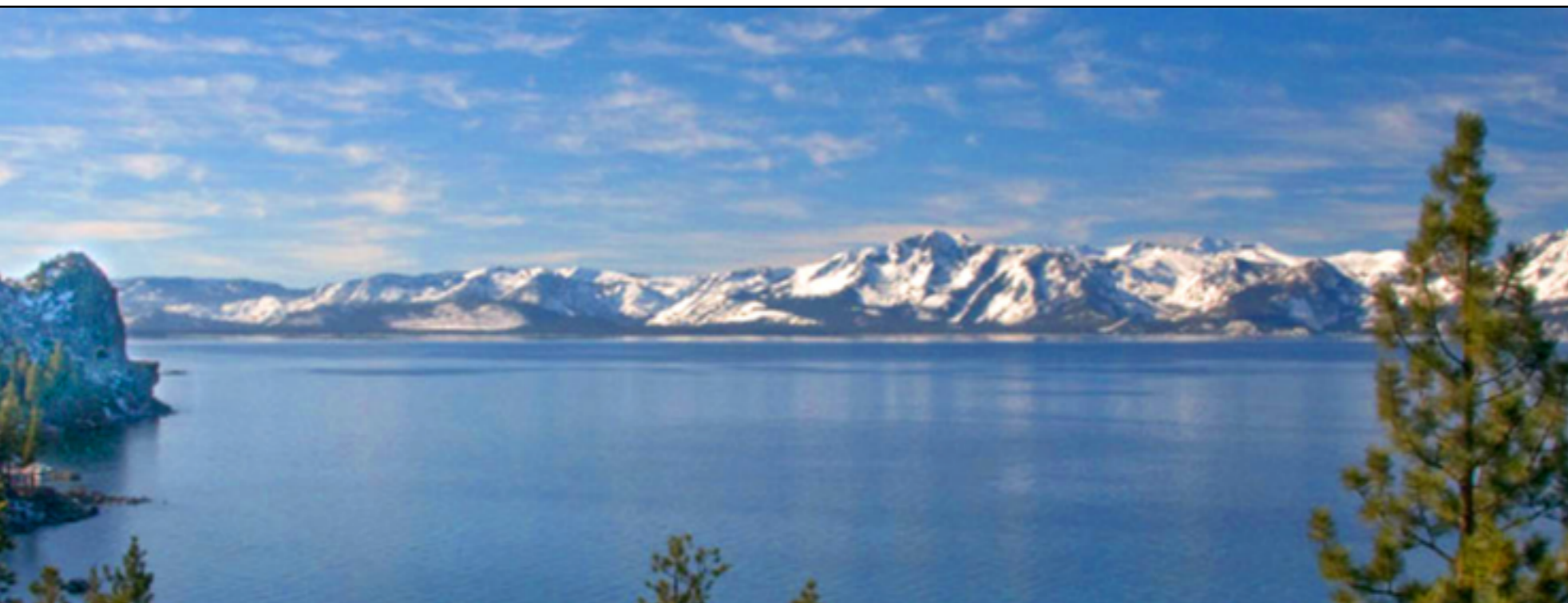
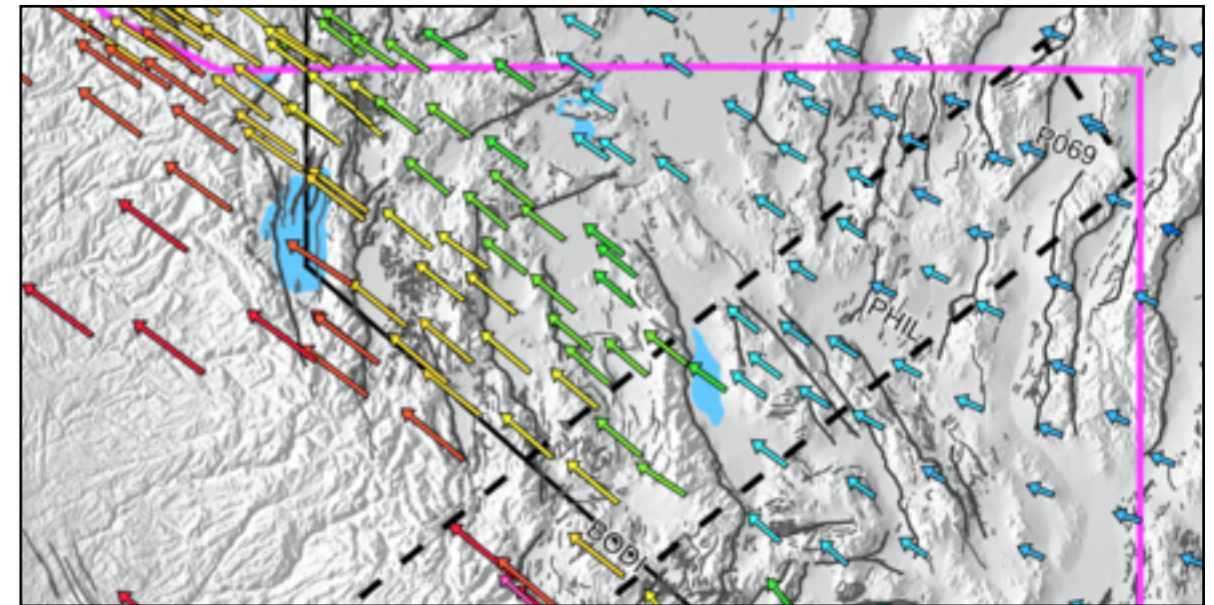


Works at the
Nevada Geodetic Laboratory
at the University of Nevada, Reno
Operates a Geodetic Network: MAGNET



Studies active crustal
deformation in the Basin
and Range, western United
States

A long way from
Johannesburg, SA



Lives in the Sierra
Nevada Mountains
near Lake Tahoe



Where it is deep winter!

The Plug and Play Collaborative Team:

University of Nevada, Reno



Geoffrey Blewitt,
UNR Institutional PI



Bill Hammond,
Co-PI



Corné Kreemer,
Co-PI



UNAVCO, Boulder



Chuck Meertens, PI

Fran Boler,
Co-PI



Major funding for project comes from NASA

Agenda For Today

- Introduction of the Plug n Play team and the Instructor (2 minutes)
- Introduction of Plug and Play: Philosophy and Scope (5-10 minutes).
- Plug and Play Data Products (30 minutes)
- Plug and Play - How to Participate (10 minutes)
- Case Study and Exercise (15 minutes)
- Time for Informal Interactions: Instructor and Operators (15 minutes)
- Done in time for the Field Trip!

Plug and Play Course Materials

<ftp://gneiss.nbmng.unr.edu/PlugNPlay/ShortCourseAfricaArrayJan2016>

Includes:

Agenda

- 1 Page Handout with description and link to signup form
- Short Course slides (.pdf of this presentation)



Plug and Play: Introduction of Scope and Philosophy

- Why are we doing this?
 - Provide FREE GPS data processing service that minimizes effort on part of network operators who contribute data
 - Reduces barriers to maximize scientific impact of GPS networks
 - Promotes of data sharing for science and society
 - Maximize discovery of data for scientific applications
 - Consistent with goals of *AfricaArray* “ .. an innovative programme to promote, strengthen and maintain a workforce of highly trained African geoscientists and researchers for Africa.”
- Who is involved? The PnP Team players:
 - UNAVCO, UNR
 - plus *beta testers* and *unfunded collaborators*, e.g. USGS, JPL, ... and you!
- Who is funding the project?
 - Collaborative NASA ACCESS program project UNAVCO and UNR
 - History of scientific, processing, and data products development at these institutions.

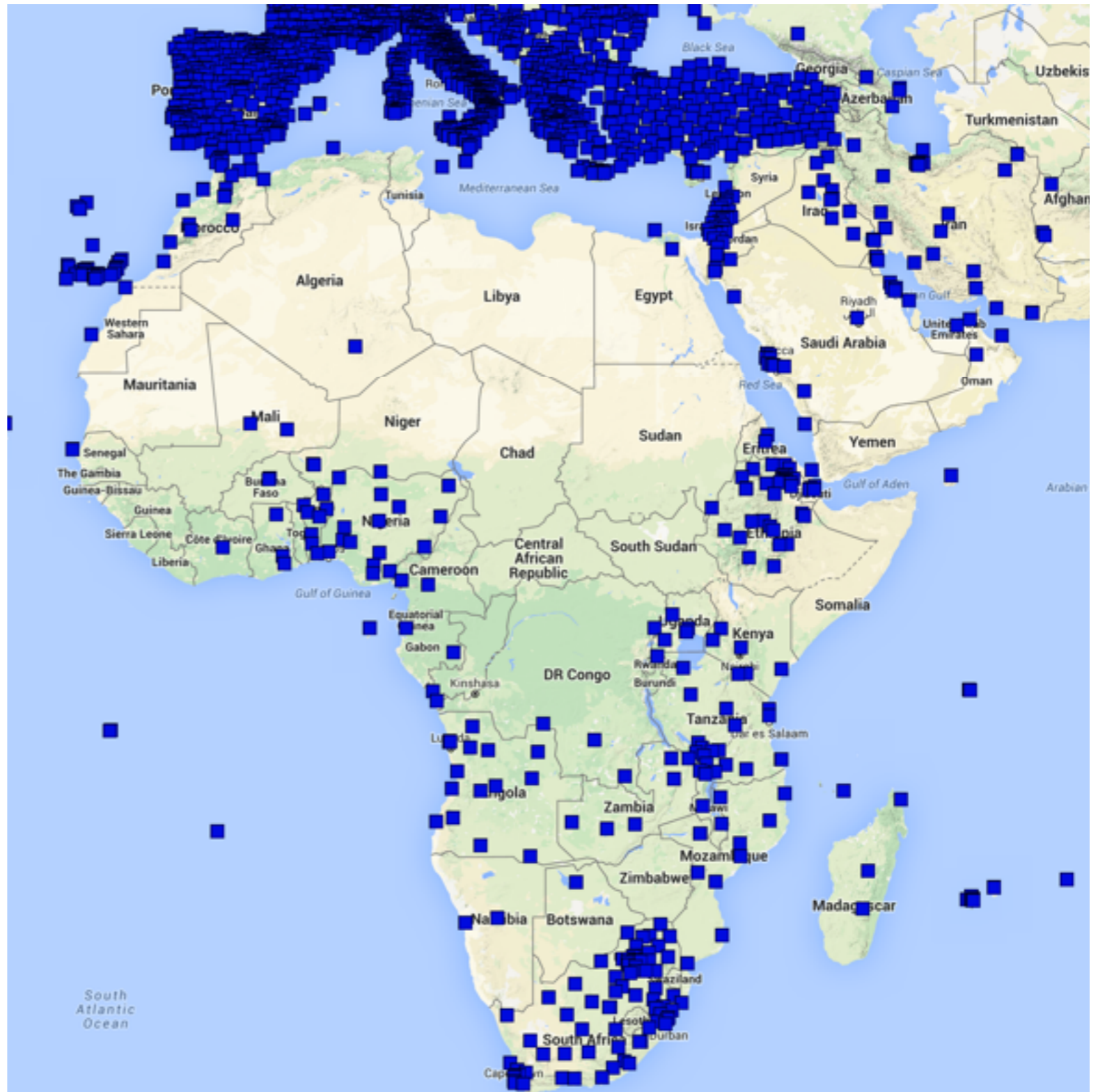
Plug and Play: Introduction of Scope and Philosophy

- What is the arrangement?
 - Network operators contribute data to UNAVCO or UNR directly
 - UNR picks up data, processes with GIPSY and generates data products (e.g. time series results files, plots, maps, velocity fields, quality control products, etc.)
 - Data products are placed on open access data products services, e.g. web pages, GSAC services. Open access.
 - **Reduces barriers to setting up or expanding networks.**
- This is a rollout of the service
 - Many of the individual ‘services’ have been available for some time in the form of research projects.
 - Much of this is in beta mode... feedback is welcome.
 - New products available (more later.)
- Plug and Play for AfricaArray
 - If your network’s data is already going to UNAVCO, you may already be getting benefits of the service. See map ...

Map of Stations in Africa Processed by NGL

see <http://geodesy.unr.edu/NGLStationPages/GPSNetMap.html>
to check for individual stations

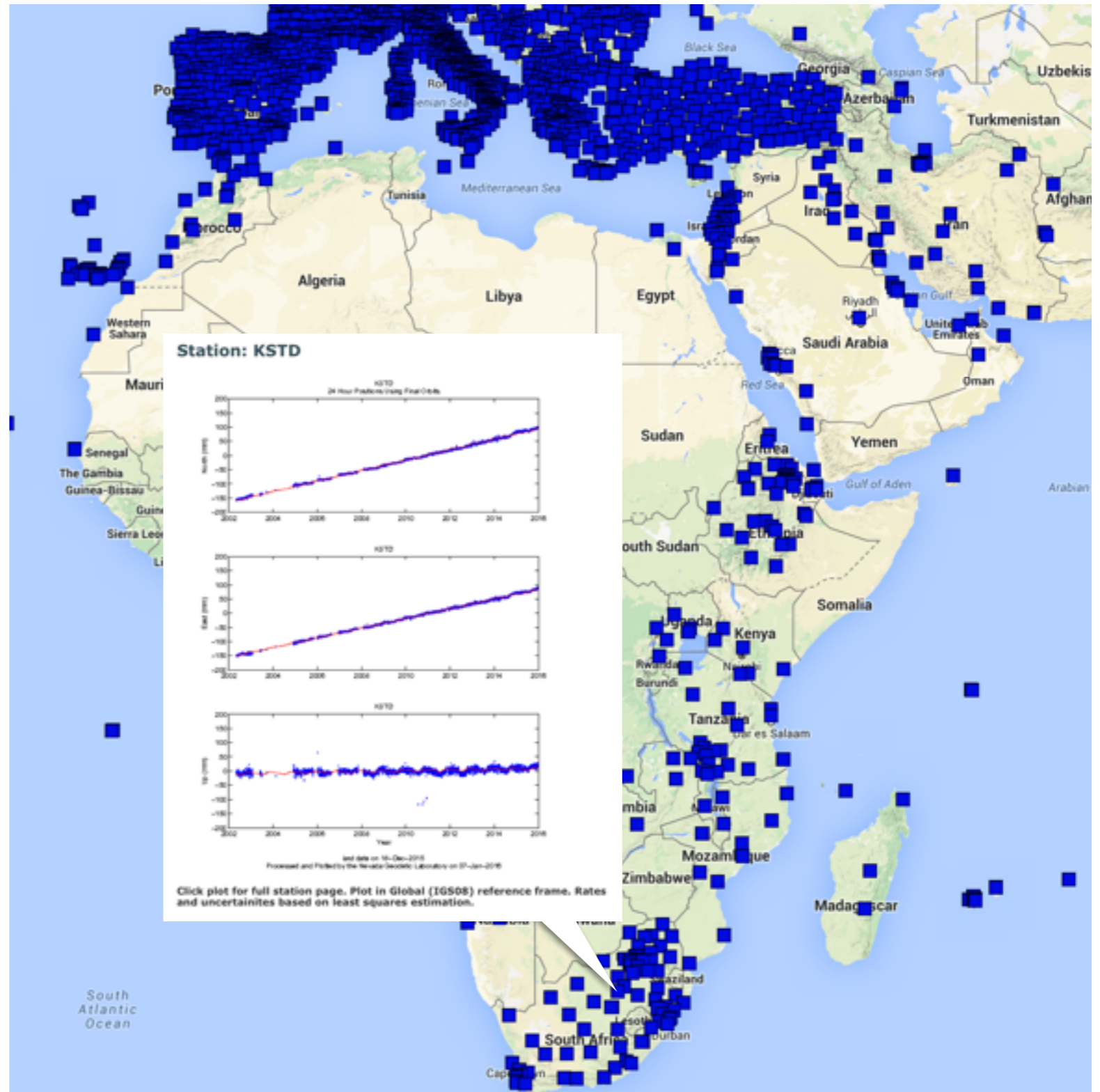
- Global zoomable Google map (Africa shown here)
- Shows all stations processed by NGL (presently >14000)
- Clickable icons provide detail about station data products and resources
- Updated every day
- Is your network here?
- It could be.
- You would have access to all data products (discussed in next section)
- Incentive to help increase number of stations in Africa



Map of Stations in Africa Processed by NGL

see <http://geodesy.unr.edu/NGLStationPages/GPSNetMap.html>
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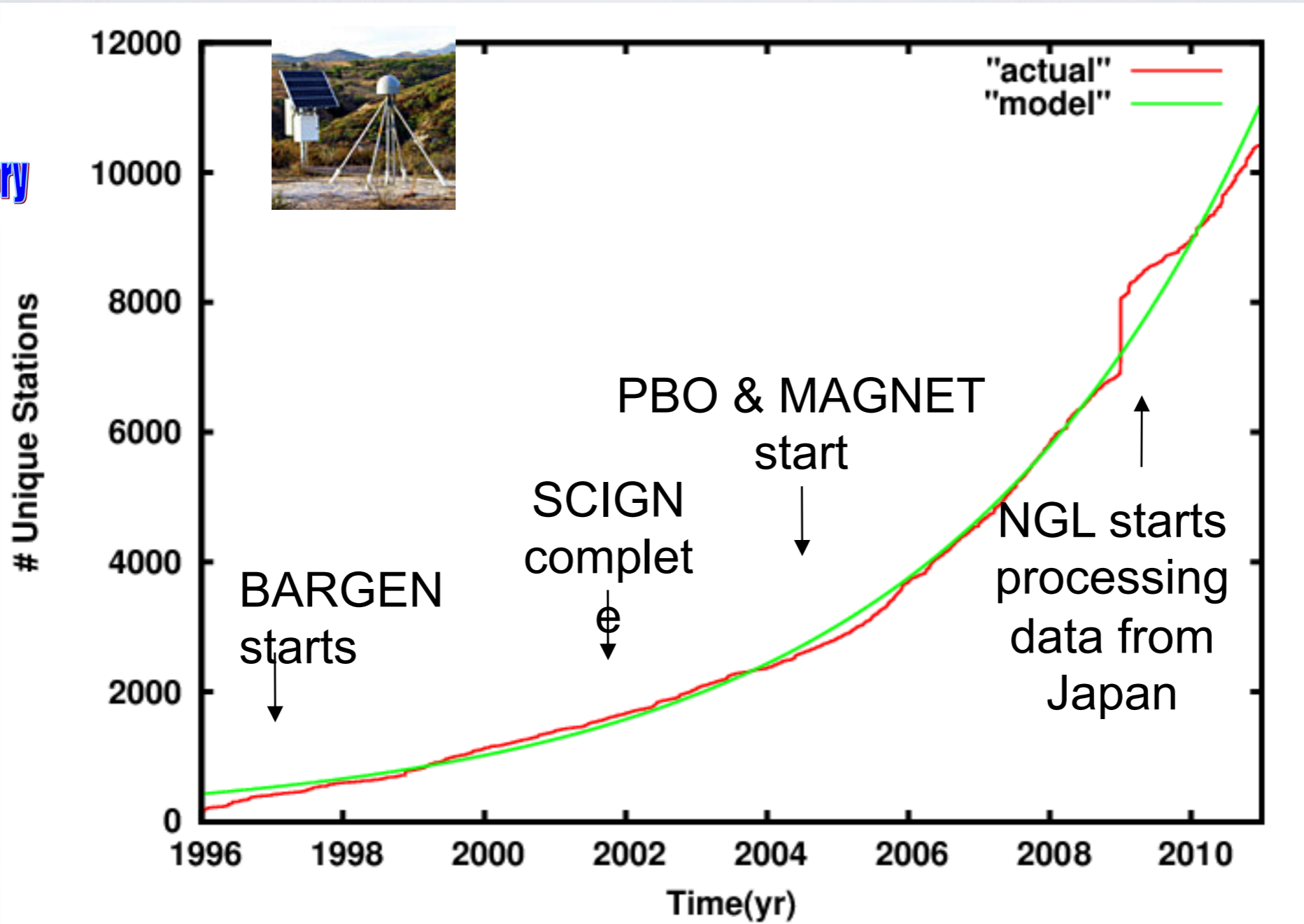
$$N = 2^{(t - 1968)/3.2}$$

Exponential explosion

in stations processed by NGL

N

Nevada
Geodetic
Laboratory



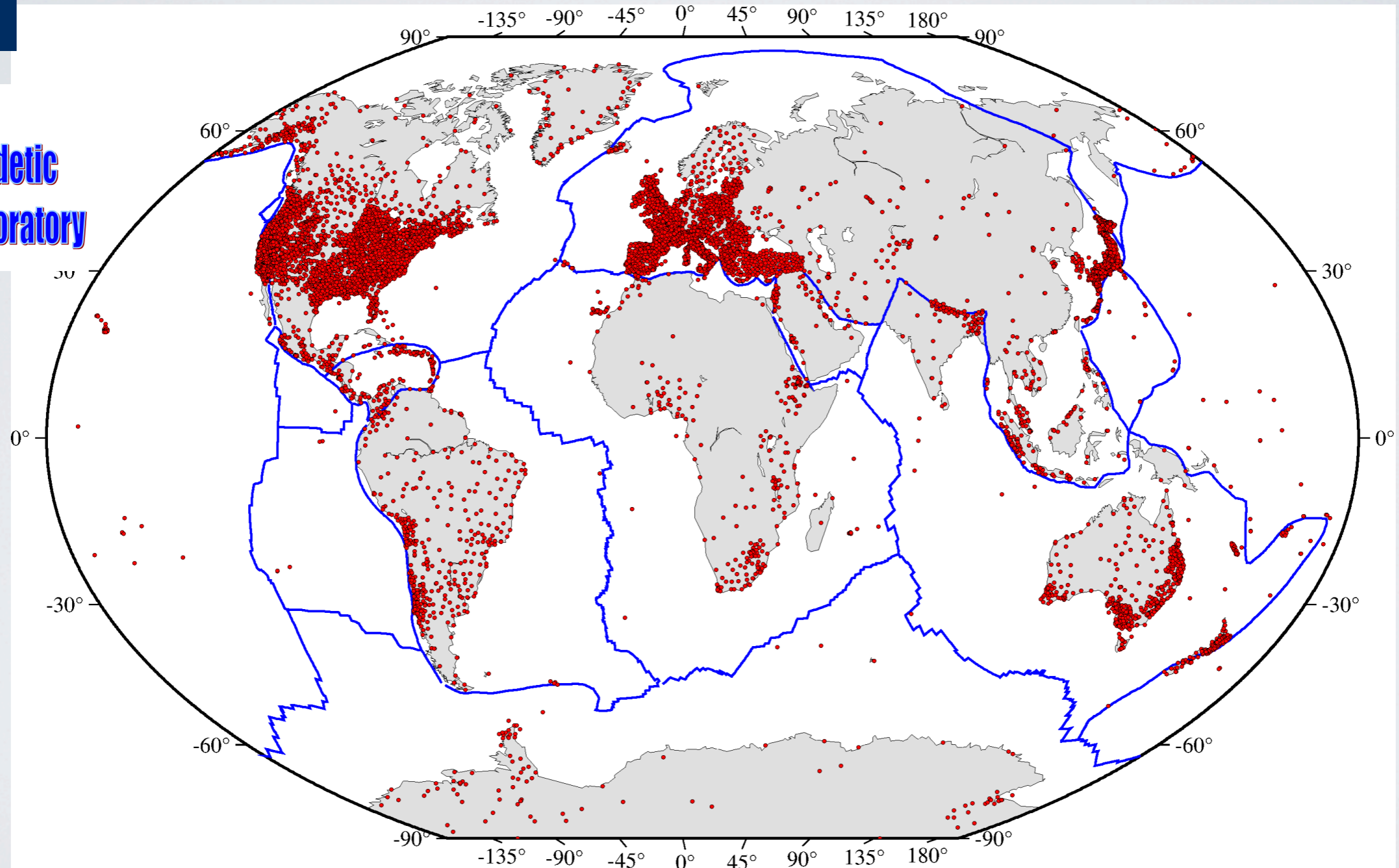
2015: Exponential explosion

>13,700 stations processed by NGL

<http://geodesy.unr.edu>

N

Nevada
Geodetic
Laboratory



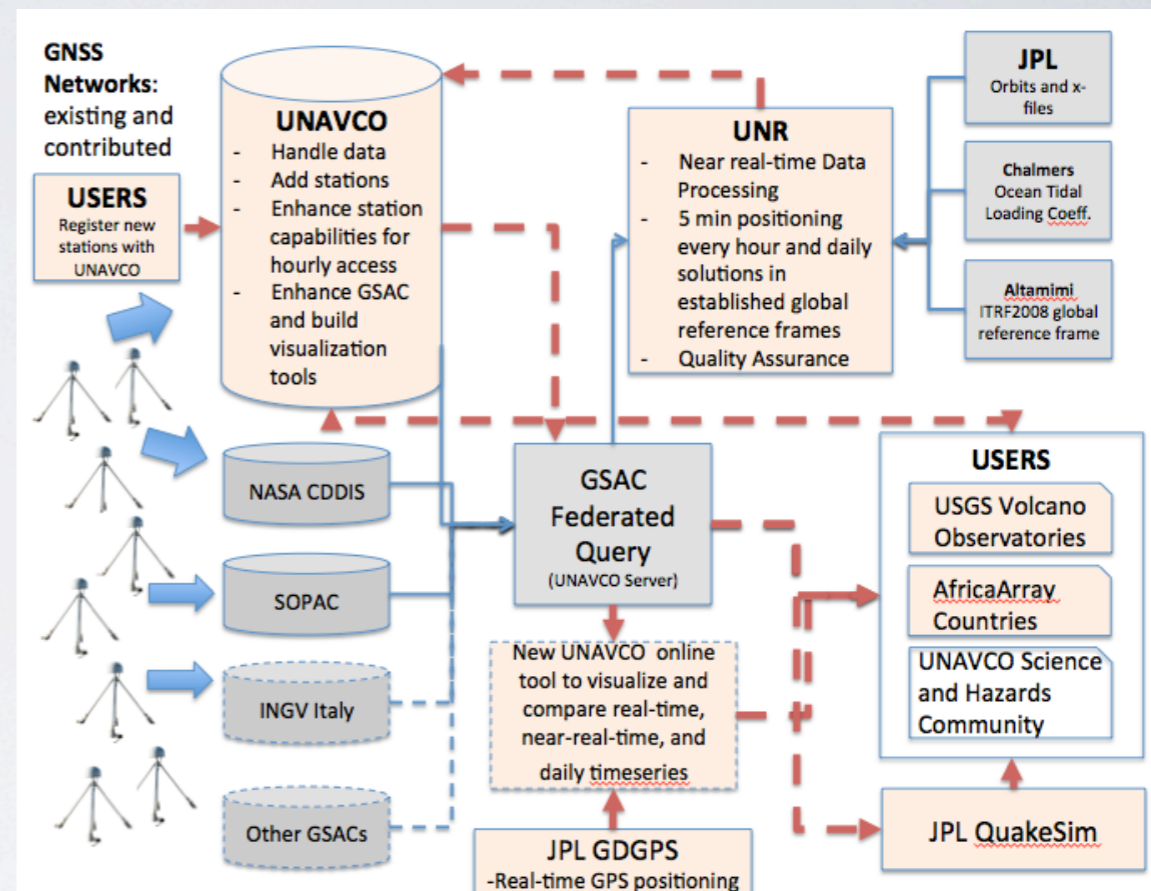
Plug and Play GPS for Earth Scientists: Providing Immediate Access to Low-Latency Geodetic Products for Rapid Modeling and Analysis of Natural Hazards

Plug and Play GPS project Goal: The plug and play concept promotes open accessibility to the scientific potential of GPS by working on the beginning and end of the GPS data processing line.

Objective 1. The system will remove barriers and extend our GPS processing system to facilitate connections to new or undiscovered GPS observations around the globe.

Objective 2. Processing outputs will include openly available daily and sub-daily position time series, time-dependent site velocities and derived strain. Data providers and other end users will have low-latency access to essential data products following the establishment of data streams.

Objective 3. Educate partners and new users in the scientific community on the goals and objectives of this project and how to participate. We will solicit their feedback on how to improve the utility of the system.



Plug and Play GPS project Workflow



Plug and Play: Future Plug n Play Events

- May 2014, NASA Awards Project
- 2015 presentation of service and available data products at workshops, conferences e.g. EarthScope, Fall AGU in San Francisco.
- AfricaArray, January 18-20, 2016
 - Rollout
 - New data products
 - First short course
- UNAVCO Science workshop, Boulder, CO March 28-31
 - Plug and Play highlighted in science sessions
- Less-Short course in Boulder, May 27, 2016
 - **Full day** workshop at UNAVCO facility
 - More extensive explanation of available tools, data resources
 - More information available soon at <http://unavco.org>

Questions?

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Plug and Play Data Products: An Introduction

Processed GPS Time Series

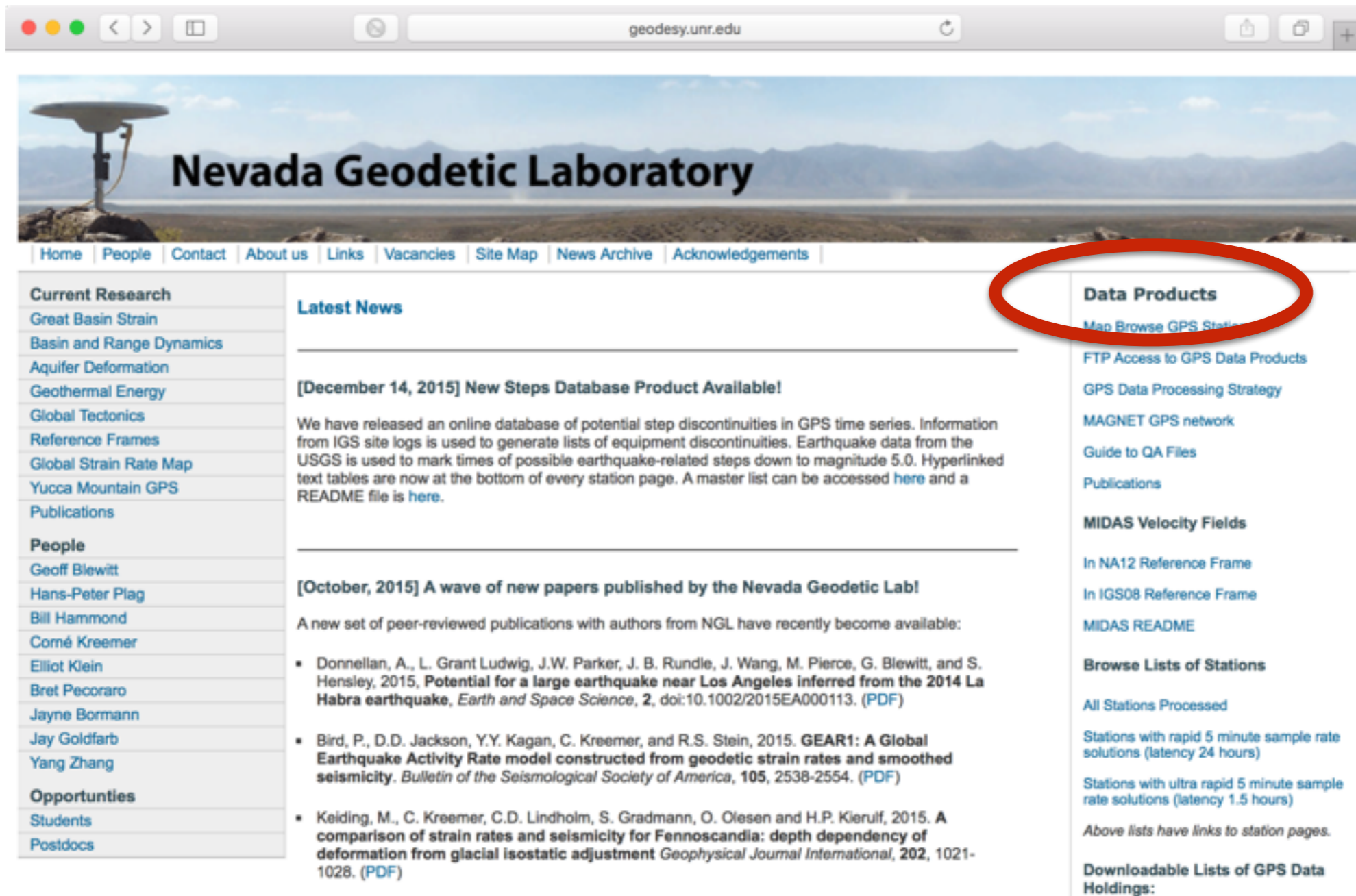
- A few processing details
- Scope of processing
- Number of stations
- Available formats of processed time series
- Available figures
- Available reference frames
- Available sample rates and latencies
- How to access and search the products

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Plug and Play Data Products: An Introduction

Where to Find Things: <http://geodesy.unr.edu>



The screenshot shows the website for the Nevada Geodetic Laboratory. The browser address bar displays geodesy.unr.edu. The main header features a photograph of a GPS antenna in a desert landscape with the text "Nevada Geodetic Laboratory". Below the header is a navigation menu with links: Home, People, Contact, About us, Links, Vacancies, Site Map, News Archive, and Acknowledgements. The main content area is divided into three columns. The left column contains sections for "Current Research" (listing topics like Great Basin Strain, Basin and Range Dynamics, etc.), "People" (listing names like Geoff Blewitt, Hans-Peter Plag, etc.), and "Opportunities" (listing Students and Postdocs). The middle column is titled "Latest News" and contains two news items: one from December 14, 2015, about a new database product, and one from October 2015 about new publications. The right column is titled "Data Products" (circled in red) and lists various data services: Map Browse GPS Stations, FTP Access to GPS Data Products, GPS Data Processing Strategy, MAGNET GPS network, Guide to QA Files, Publications, MIDAS Velocity Fields (with sub-links for NA12 and IGS08 reference frames, and a README), Browse Lists of Stations (with sub-links for All Stations Processed, rapid 5-minute sample rate solutions, and ultra-rapid 5-minute sample rate solutions), and Downloadable Lists of GPS Data Holdings.

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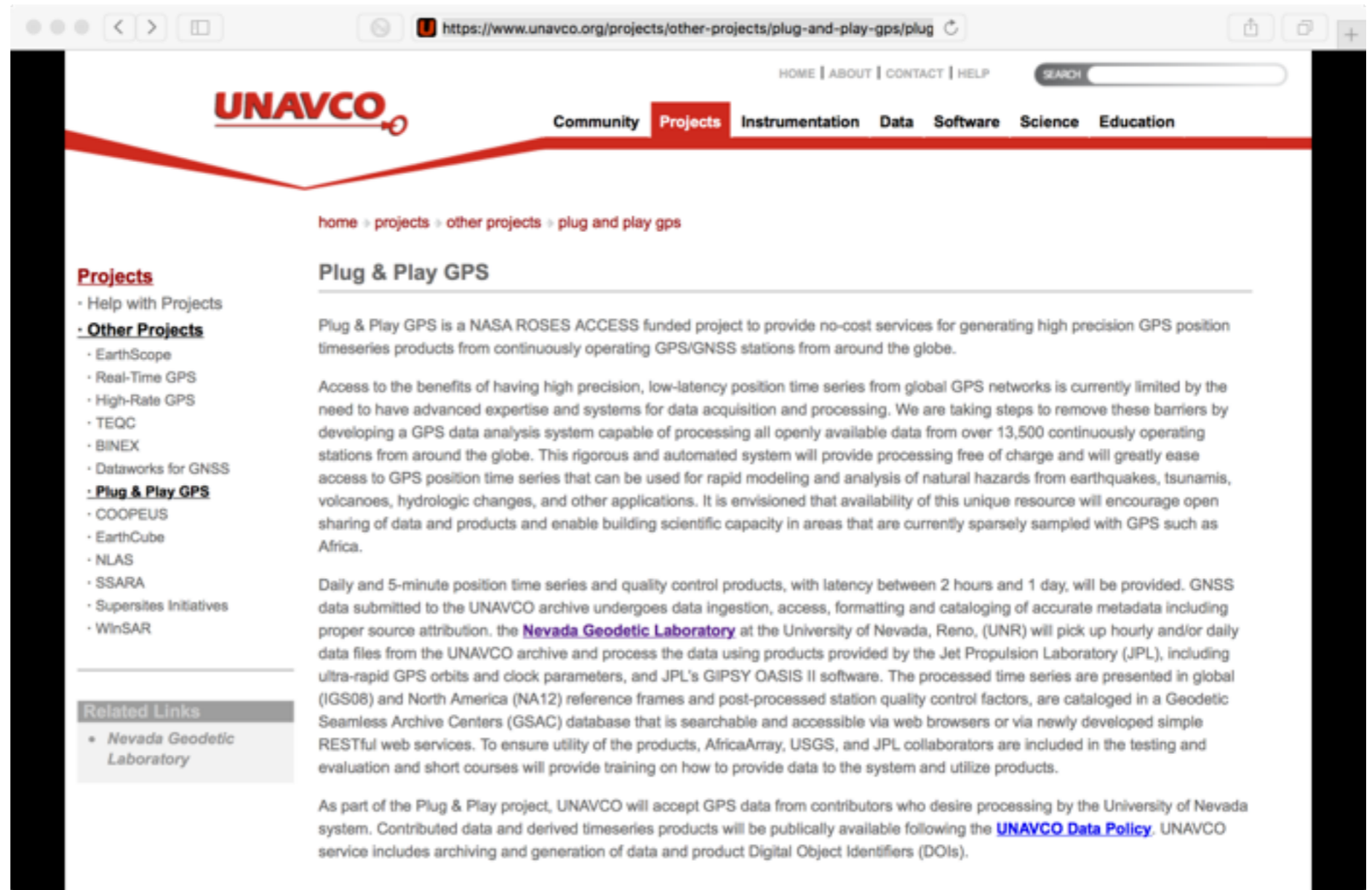


Plug and Play Data Products: An Introduction

Where to Find Things: <https://www.unavco.org>

<https://www.unavco.org/projects/other-projects/plug-and-play-gps/plug-and-play-gps.html>

- These are the main portals
- Several search options for products are available
- More later



The screenshot shows the UNAVCO website's 'Plug & Play GPS' page. The browser address bar displays the URL: <https://www.unavco.org/projects/other-projects/plug-and-play-gps/plug>. The website header includes the UNAVCO logo and navigation links: HOME | ABOUT | CONTACT | HELP. A search bar is also present. The main navigation menu includes: Community, Projects (highlighted), Instrumentation, Data, Software, Science, and Education. The breadcrumb trail reads: home > projects > other projects > plug and play gps. The page title is 'Plug & Play GPS'. The main content area describes the project as a NASA ROSES ACCESS funded initiative providing no-cost services for high-precision GPS position timeseries. It details the system's capabilities, including processing data from over 13,500 stations and providing products in global (IGS08) and North America (NA12) reference frames. A 'Related Links' section points to the Nevada Geodetic Laboratory. The footer mentions that UNAVCO will accept GPS data from contributors for processing by the University of Nevada system, with products available under the UNAVCO Data Policy.

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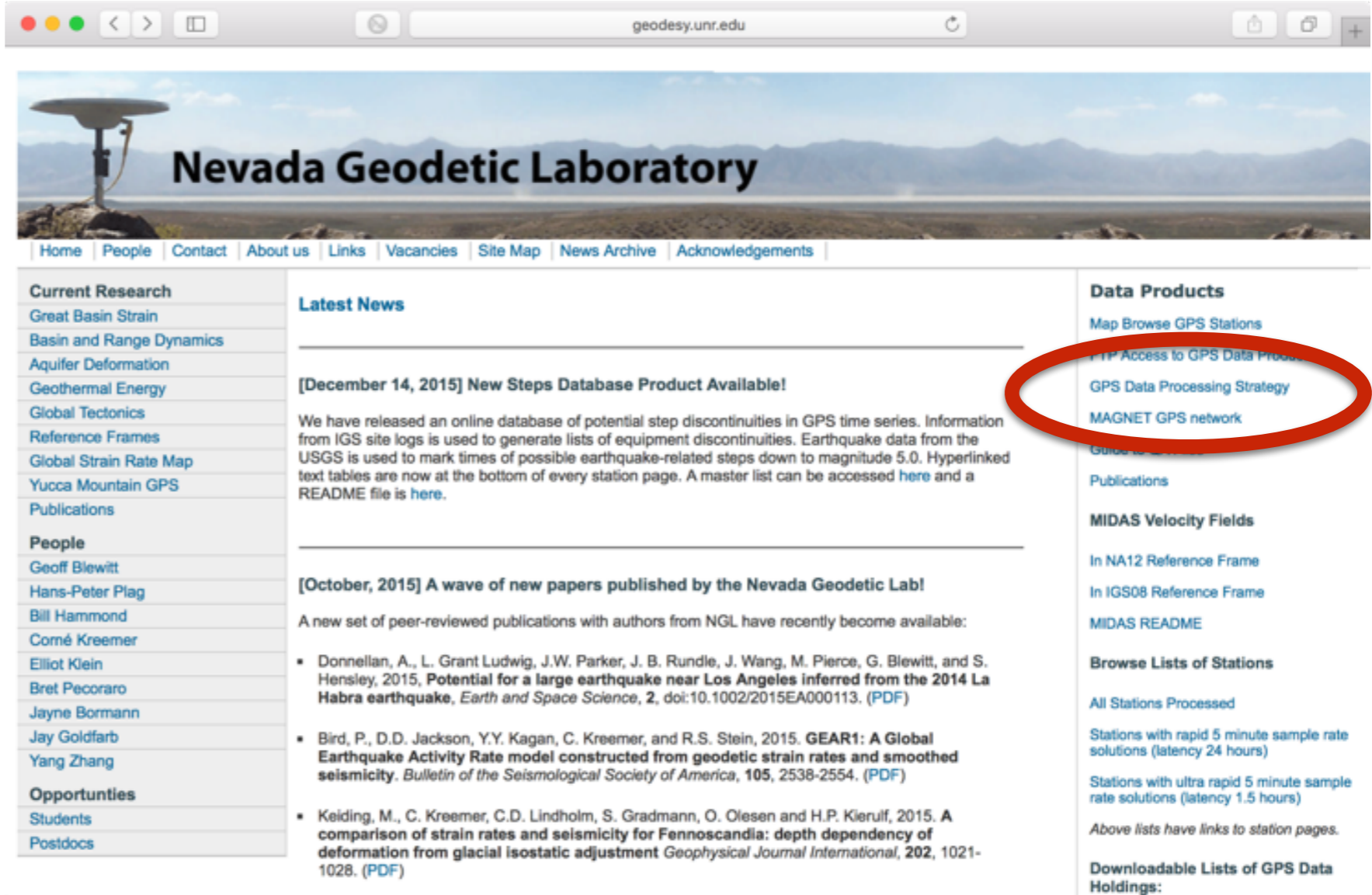


Plug and Play Data Products: An Introduction

Processing

- GIPSY/OASIS software
- Precise Point Positioning
- Use JPL products (e.g. orbits, clock corrections)

- Description of all models documented under “GPS Data Processing Strategy” e.g.:
 - estimated parameters
 - Earth orientation
 - troposphere model
 - ionosphere model
 - Earth tide
 - Ocean tidal loading
 - antenna corrections
 - solar radiation
 - ambiguities, etc.



The screenshot shows the website for the Nevada Geodetic Laboratory (geodesy.unr.edu). The page features a header with the lab's name and a navigation menu. A sidebar on the left lists 'Current Research' and 'People'. The main content area displays 'Latest News' with two articles. A sidebar on the right lists 'Data Products', with 'GPS Data Processing Strategy' circled in red. Other data products include 'MAGNET GPS network', 'MIDAS Velocity Fields', and 'Browse Lists of Stations'.

<http://geodesy.unr.edu>

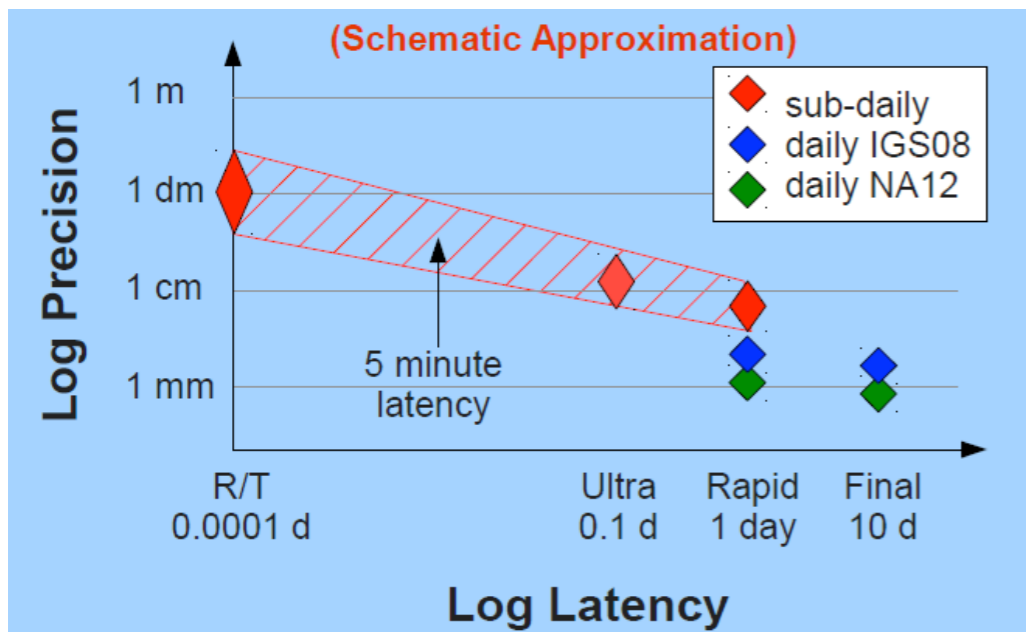
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Plug and Play Data Products: An Introduction

Latencies

- Processing performed using JPL orbits:
 - Final (1-2 weeks)
 - Rapid (24 hours)
 - Ultrarapid (1-2 hours)
- More rapid are least accurate
- We need access to hourly RINEX to get Ultrarapid latency



Data Flow	% of GSAC Stations available	Data Sample Rate	Position Solution Sample Rate	Position Solution Latency	Position Solution Precision	Position Solution Providers
Daily File Download	95%	15 second	Once/day	Rapid 1-2 Days	H: 1.5 mm V: 5 mm	UNR (All stations proposed) PBO Analysis Centers (only ~1,100 PBO stations); Individual investigators or agencies;
				Final 1-2 weeks	H: 1.5 mm V: 5 mm	
Hourly File Download	20%	15 second	Once/5 minutes	Ultrarapid 1-2 hours; Rapid 1 day	PPP:10 mm (global)	UNR (Proposed)
Streams	15%	1 second	Once/second	1 second	RTK Short Baseline (<10km) <1cm RTK Long Baseline (10km-300km) 1-50cm PPP Kinematic (global) 5-10 cm	PBO, NGS (both in development); JPL GDGPS (~100 stations); limited number of other groups

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Plug and Play Data Products: An Introduction

Number of Stations

as of 1/10/2015

24 Hour Finals

14112 stations in IGS08
6569 stations in NA12

24 Hour Rapids

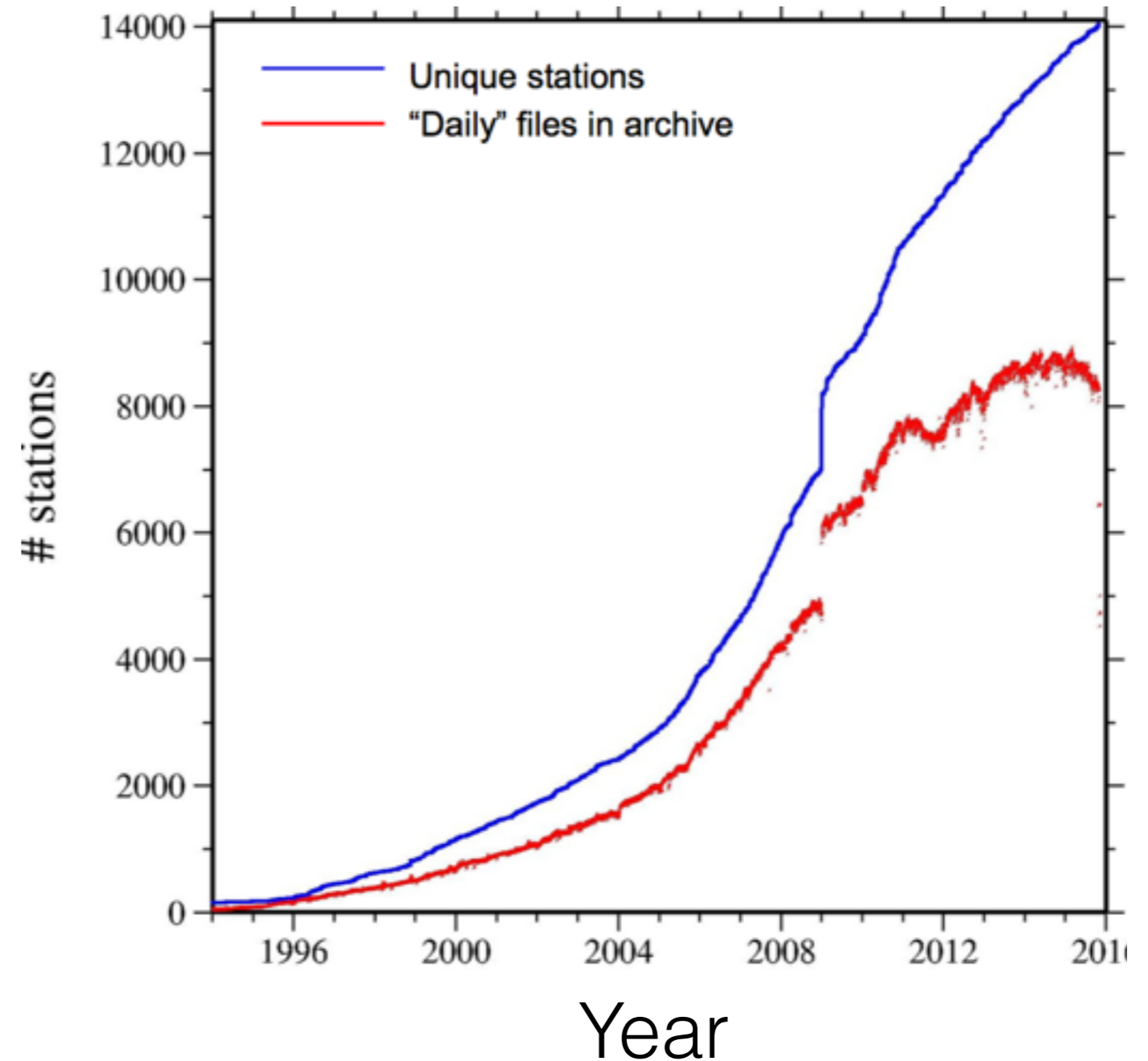
10253 stations in FID
5193 stations in NA12

5 Minute Rapids

5,050,019 kenv station-day files

5 Minute UltraRapids

1,799,694 kenv station-day files



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Plug and Play Data Products: An Introduction

Station Pages

- One page for each station
- Links to time series in text format
- Machine readable via http (e.g. curl, wget). Write your own scripts.
- Google map shows location
- Time series in east, north, up and x,y,z format with “readme” text files that describe formats
- Links to QA files
- Scroll down for
 - Time series plots in e, n, u
 - Separate tabs for different
 - reference frames
 - latencies
- Link to station operator attributes from RINEX headers



geodesy.unr.edu

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[Home](#) | [Browse Global Station List](#) | [Browse Rapid Station List](#) | [Browse Ultra Rapid Station List](#) | [Map Browse](#) | [Acknowledgements](#)

Station ID : P090

Station operator information:
from RINEX headers

Data processed by:
Geoffrey Blewitt, Nevada Geodetic Lab.

Latitude: 39.573
Longitude: -119.800
Height: 1503.649 meters

Time Series Data (ascii text)		
24 Hour Final Solutions		
IGS08	env	xyz
NA12	env	xyz
24 Hour Rapid Solutions		
FID (~IGS08)	env	
NA12	env	
env readme	xyz readme	
QA files	ftp link	
Rapid 5 Minute Solutions Available Next Day (8-32 hr. latency)		
env	ftp link	
Ultra Rapid 5 Minute Solutions Available Next Hour (1-2 hr. latency)		



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geodesy.unr.edu

Nevada Geodetic Laboratory

Home | Browse Global Station List | Browse Rapid Station List | Browse Ultra Rapid Station List | Map Browse | Acknowledgements

Station ID : P090

Station operator information:
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Latitude: 39.573
Longitude: -119.800
Height: 1503.649 meters

click!

Time Series Data (ascii text)		
24 Hour Final Solutions		
IGS08	env	xyz
NA12	env	xyz
24 Hour Rapid Solutions		
FID (~IGS08)	env	
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site	YYMMDD	yyyy.yyyy	_MJD	week	d	reflon_e0(m)	_east(m)	_n0(m)	_north(m)	u0(m)	_up(m)	_ant(m)	
P090	07NOV10	2007.8576	54414	1452	7	-119.8	12	0.884938	4382097	0.181664	1503	0.658770	0.0083
		0.000480	0.000602	0.001807	0.013978	-0.052295	-0.165112						
P090	07NOV11	2007.8604	54415	1453	1	-119.8	12	0.888054	4382097	0.183439	1503	0.646588	0.0083
		0.000477	0.000602	0.001790	0.008858	-0.042988	-0.142836						
P090	07NOV12	2007.8631	54416	1453	2	-119.8	12	0.887598	4382097	0.180896	1503	0.649893	0.0083
		0.000477	0.000604	0.001809	0.005412	-0.043056	-0.169644						
P090	07NOV13	2007.8658	54417	1453	3	-119.8	12	0.885870	4382097	0.181491	1503	0.655146	0.0083
		0.000479	0.000599	0.001801	0.011046	-0.047243	-0.157011						
P090	07NOV14	2007.8686	54418	1453	4	-119.8	12	0.886035	4382097	0.183396	1503	0.652920	0.0083
		0.000476	0.000598	0.001785	0.016225	-0.056133	-0.143679						
P090	07NOV15	2007.8713	54419	1453	5	-119.8	12	0.887127	4382097	0.182818	1503	0.650555	0.0083
		0.000476	0.000597	0.001778	0.007844	-0.033799	-0.158605						
P090	07NOV16	2007.8741	54420	1453	6	-119.8	12	0.886203	4382097	0.180841	1503	0.654308	0.0083
		0.000477	0.000599	0.001797	0.026682	-0.056293	-0.152377						
P090	07NOV17	2007.8768	54421	1453	7	-119.8	12	0.890428	4382097	0.179823	1503	0.653142	0.0083
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P090	07NOV18	2007.8795	54422	1454	1	-119.8	12	0.888664	4382097	0.181148	1503	0.650954	0.0083
		0.000476	0.000599	0.001785	0.018948	-0.055773	-0.143269						
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P090	07NOV21	2007.8877	54425	1454	4	-119.8	12	0.887623	4382097	0.182016	1503	0.649429	0.0083
		0.000479	0.000598	0.001784	0.014164	-0.030924	-0.160704						
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		0.000488	0.000608	0.001826	-0.008442	-0.035085	-0.132720						
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P090	07NOV26	2007.9014	54430	1455	2	-119.8	12	0.885591	4382097	0.182899	1503	0.649698	0.0083
		0.000484	0.000603	0.001823	0.012898	-0.048825	-0.159544						
P090	07NOV27	2007.9042	54431	1455	3	-119.8	12	0.886508	4382097	0.181938	1503	0.647079	0.0083
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		0.000483	0.000602	0.001807	0.006177	-0.032891	-0.166836						
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P090	07NOV30	2007.9124	54434	1455	6	-119.8	12	0.885322	4382097	0.182828	1503	0.643178	0.0083
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P090	07DEC01	2007.9151	54435	1455	7	-119.8	12	0.884499	4382097	0.182954	1503	0.640113	0.0083
		0.000482	0.000599	0.001809	0.018826	-0.056683	-0.160752						
P090	07DEC02	2007.9179	54436	1456	1	-119.8	12	0.886850	4382097	0.180146	1503	0.651966	0.0083
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P090	07DEC03	2007.9206	54437	1456	2	-119.8	12	0.885727	4382097	0.179291	1503	0.660595	0.0083
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P090	07DEC04	2007.9233	54438	1456	3	-119.8	12	0.887167	4382097	0.179312	1503	0.660219	0.0083
		0.000483	0.000608	0.001820	0.001620	-0.035896	-0.147609						
P090	07DEC05	2007.9261	54439	1456	4	-119.8	12	0.886050	4382097	0.181449	1503	0.650758	0.0083
		0.000482	0.000601	0.001793	0.002020	-0.047098	-0.145232						
P090	07DEC06	2007.9288	54440	1456	5	-119.8	12	0.886311	4382097	0.184532	1503	0.655698	0.0083

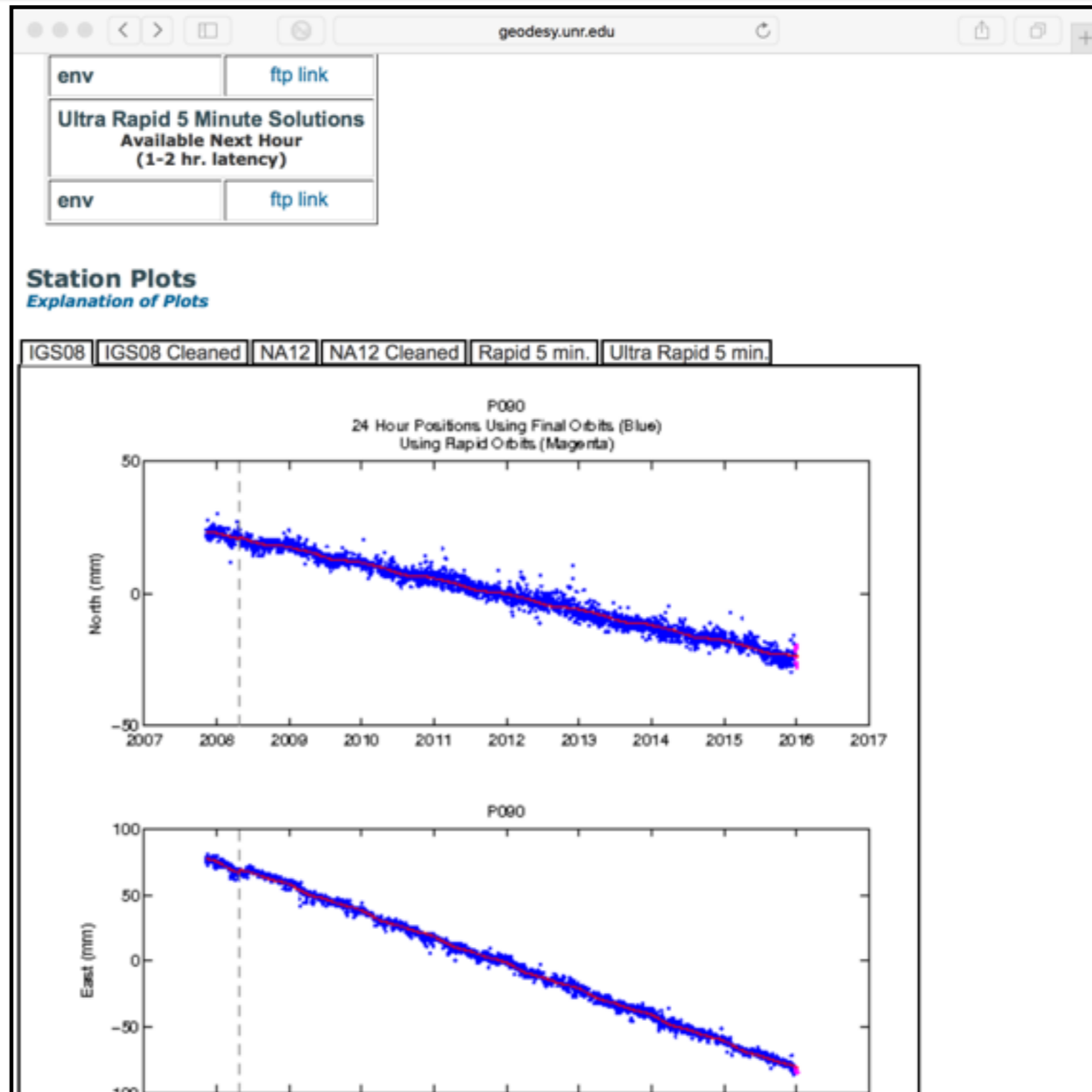
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- Google map shows location
- Time series in east, north, up and x,y,z format with “readme” text files that describe formats
- Links to QA files
- Scroll down for
 - Time series plots in e, n, u
 - Separate tabs for different
 - reference frames
 - latencies



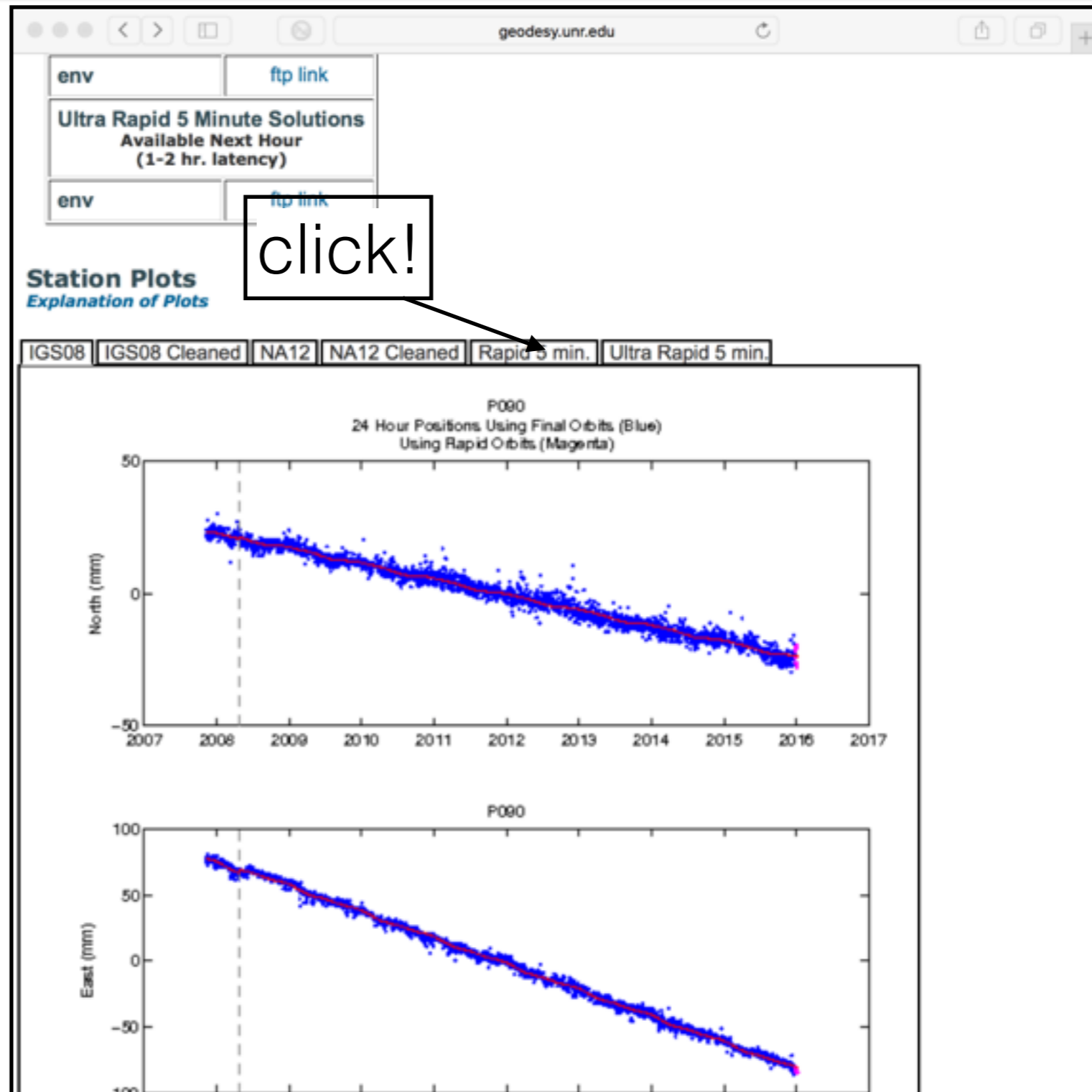
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Plug and Play Data Products: An Introduction

Station Pages

- One page for each station
- Links to time series in text format
- Machine readable via http (e.g. curl, wget). Write your own scripts.
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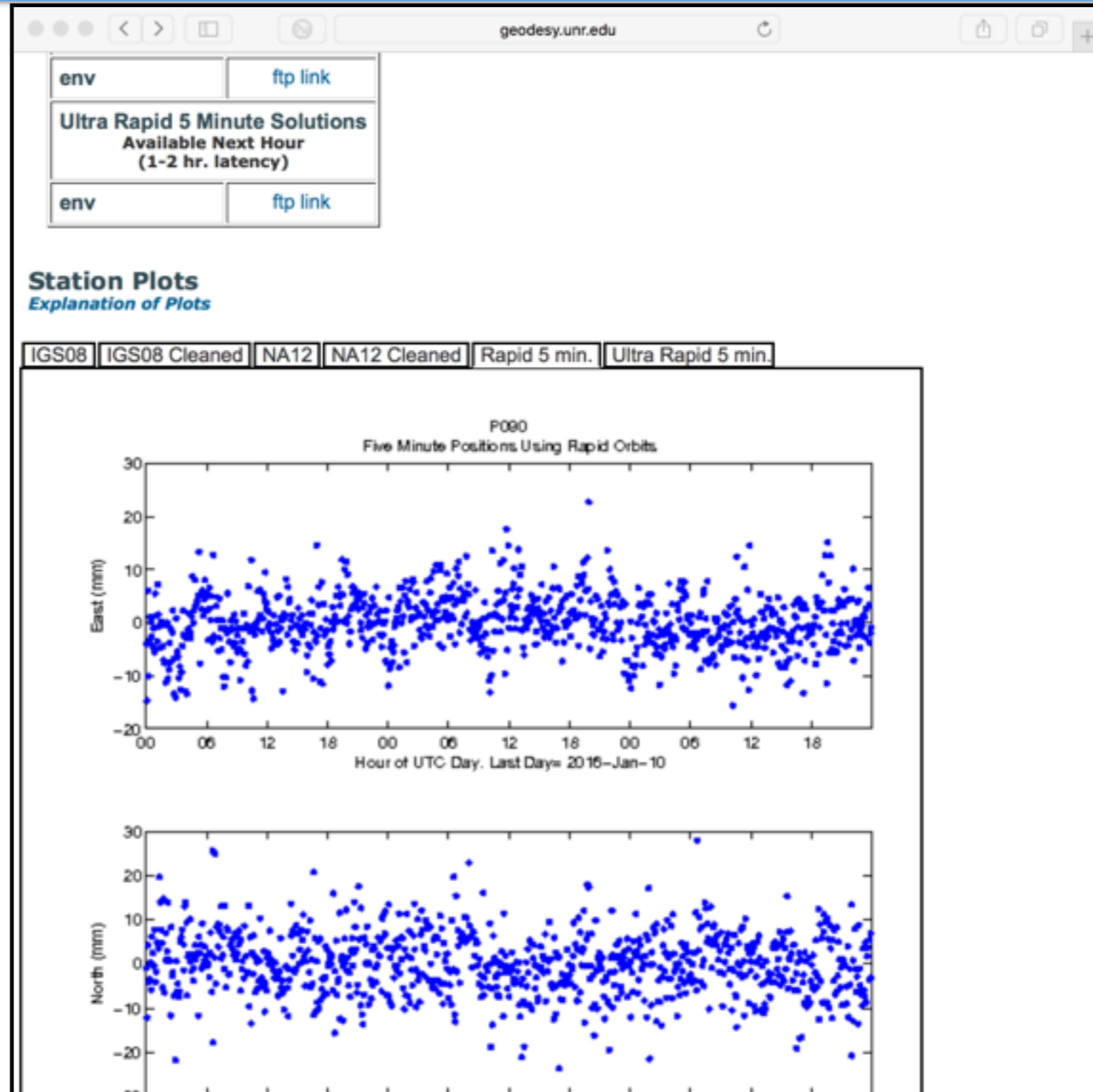
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Plug and Play Data Products: An Introduction

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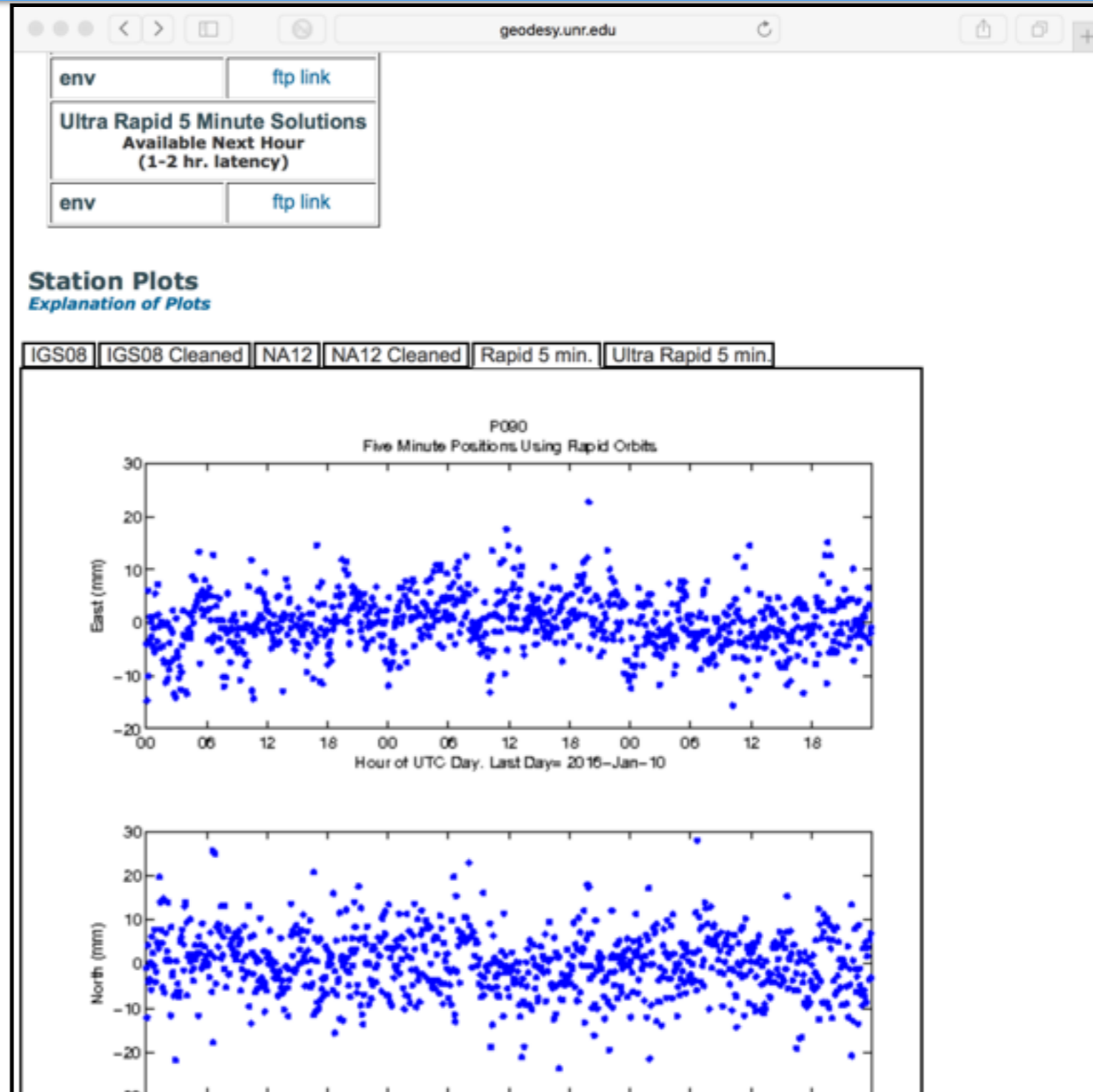
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Plug and Play Data Products: An Introduction

Station Pages

- One page for each station
- Links to time series in text format
- Machine readable via http (e.g. curl, wget). Write your own scripts.
- Google map shows location
- Time series in east, north, up and x,y,z format with “readme” text files that describe formats
- Links to QA files
- Scroll down for
 - Time series plots in e, n, u
 - Separate tabs for different
 - reference frames
 - latencies
- Useful when earthquakes occur



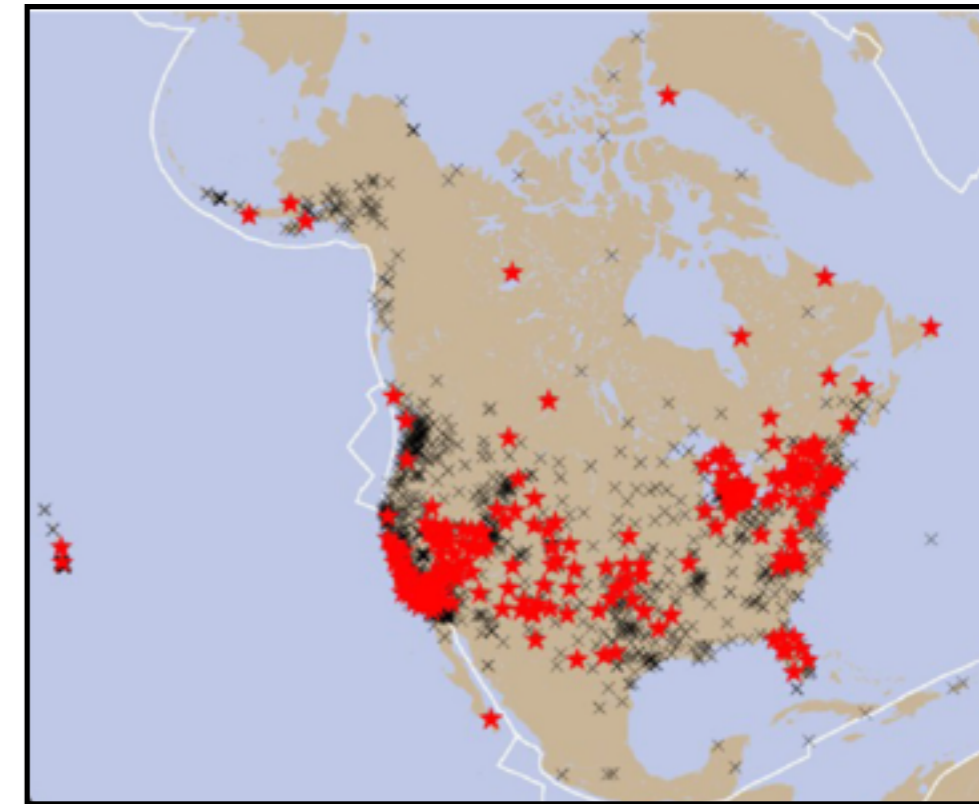
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Plug and Play Data Products: An Introduction

Reference Frames

- Currently two frames offered:
 - **IGS08**, GPS version of ITRF08
 - **NA12** a North America Fixed
- Plate-specific frames have plate rotation and common mode signal (on plate scale) removed
- Less scatter in time series compared to IGS08.
- Plans in works for custom frames for
 - Africa
 - South America
 - Eurasia
 - Pacific
 - etc.



Blewitt, G., C. Kreemer, W.C. Hammond and J. Goldfarb (2013). Terrestrial reference frame NA12 for crustal deformation studies in North America, *Journal of Geodynamics*, 72, pp. 11-24, ISSN 0264-3707

Altamimi, Z., X. Collilieux, L. Métivier, 2011, ITRF2008: an improved solution of the international terrestrial reference frame, *J. Geodesy*, DOI 10.1007/s00190-011-0444-4.

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Searching for What You Want

Options:

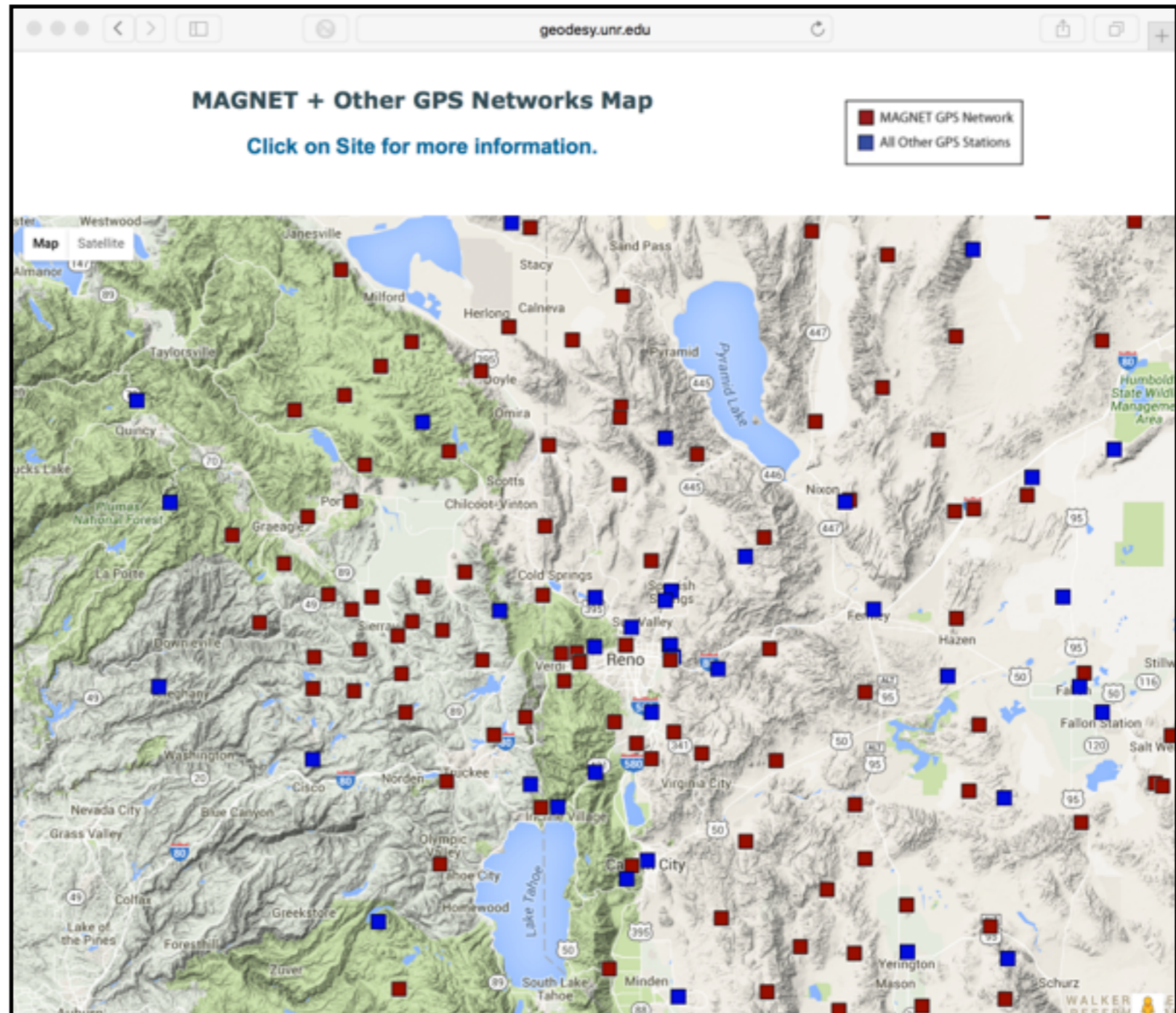
- Map Search - using the Google map
- Station Lists - text search
- Online Data Holdings - machine readable files
- GSAC online query tools

Plug and Play Data Products: An Introduction

Map Search

(good if you know geographic location but not station names)

- Hover cursor to see name of station before clicking
- zoom, pan, the usual way
- click to get station page



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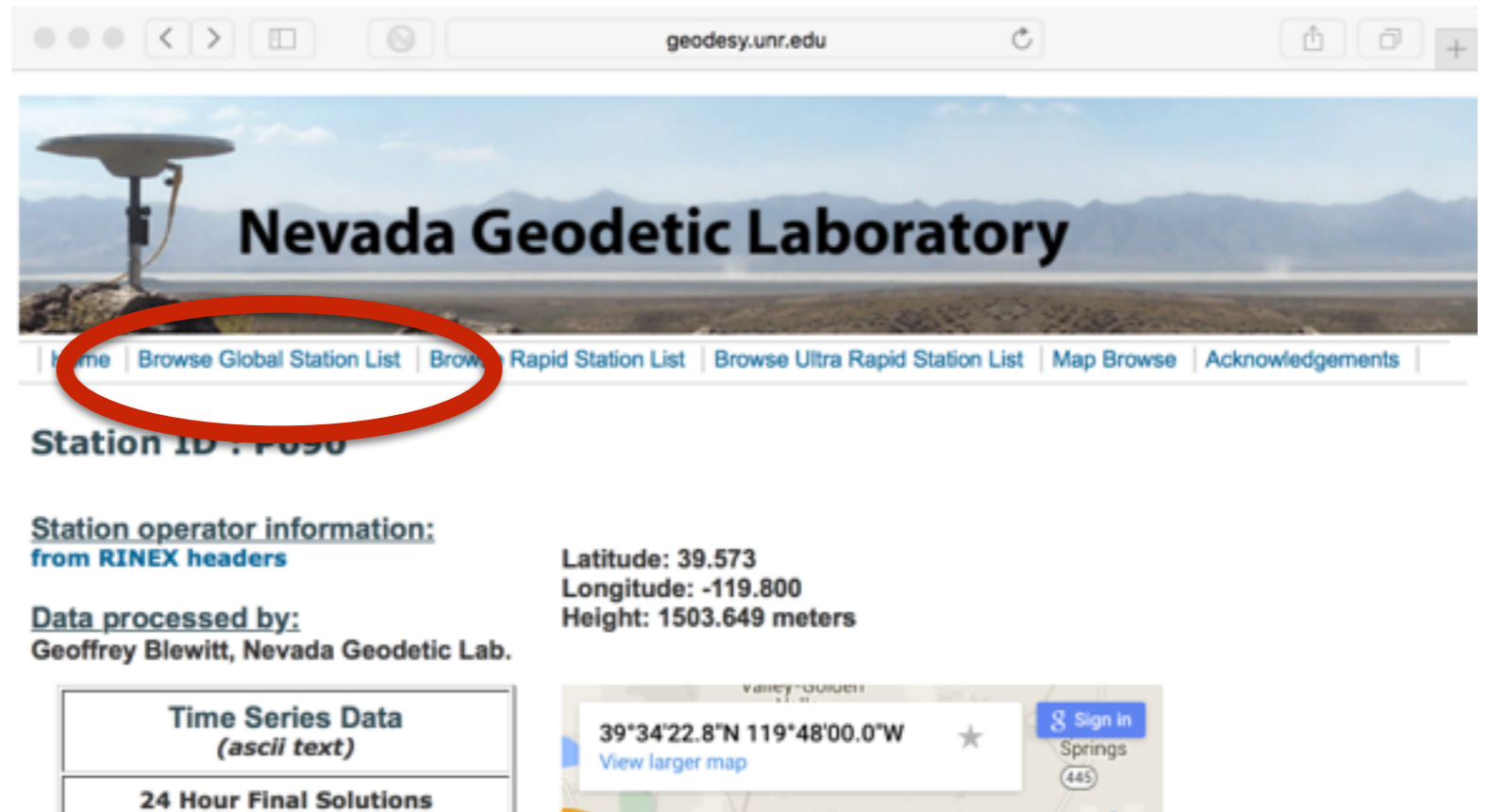


Plug and Play Data Products: An Introduction

Text Search by Station Name

(good if you know what station you are looking for)

- Step 1, choose what latency you want (final, rapid, ultra rapid)
- Step 2, click on link
- Step 3, get list .
- Step 4, use find function in browser to go right to station



The screenshot shows the website for the Nevada Geodetic Laboratory at geodesy.unr.edu. The page features a navigation menu with links: Home, Browse Global Station List, Browse Rapid Station List, Browse Ultra Rapid Station List, Map Browse, and Acknowledgements. The 'Browse Rapid Station List' link is circled in red. Below the navigation, the page displays 'Station ID: P090'. Under 'Station operator information: from RINEX headers', it lists 'Data processed by: Geoffrey Blewitt, Nevada Geodetic Lab.' and provides coordinates: Latitude: 39.573, Longitude: -119.800, and Height: 1503.649 meters. There are two buttons: 'Time Series Data (ascii text)' and '24 Hour Final Solutions'. A map widget shows the station location at 39°34'22.8"N 119°48'00.0"W with a 'View larger map' link and a 'Sign in Springs' button.

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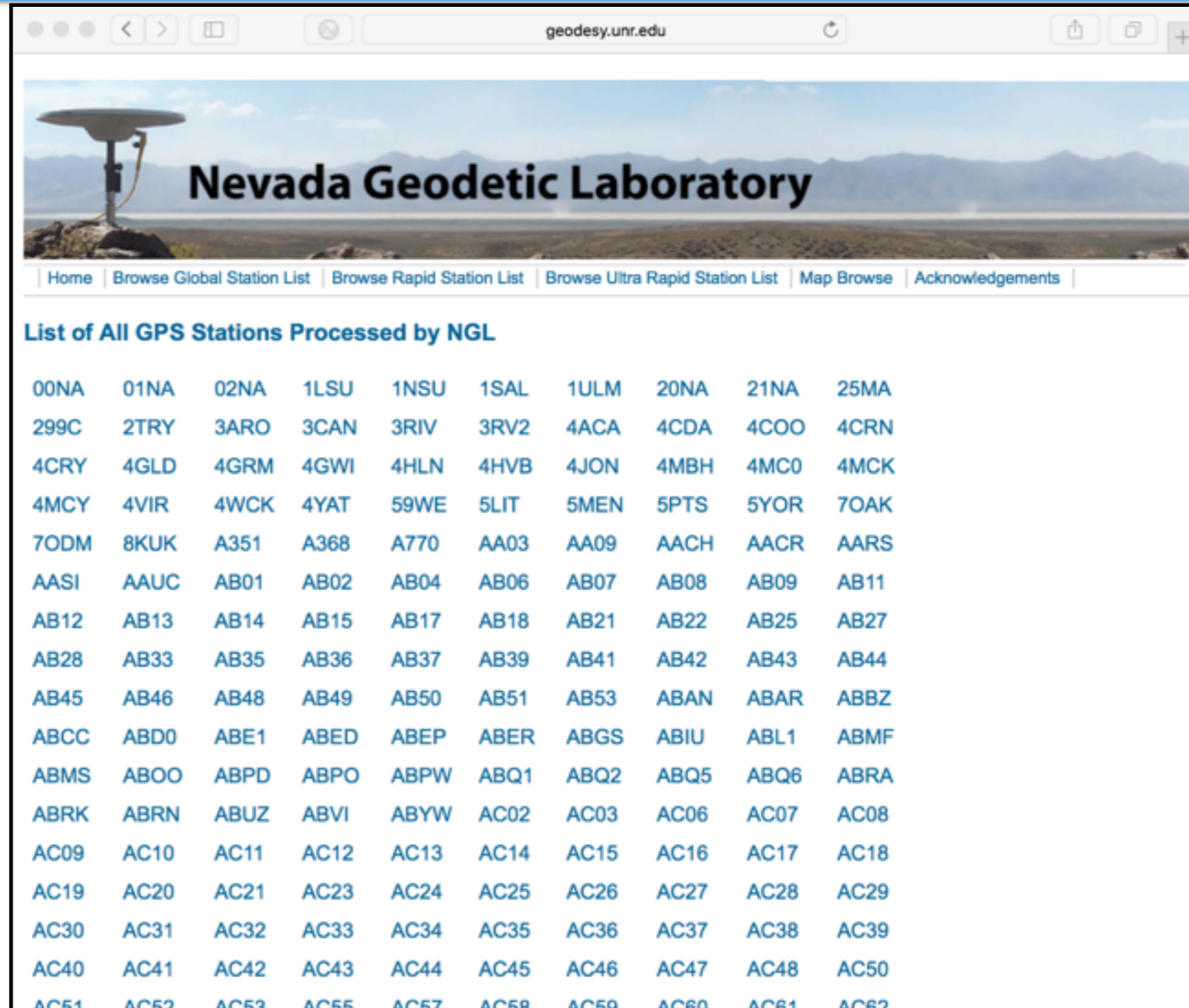


Plug and Play Data Products: An Introduction

Text Search by Station Name

(good if you know what station you are looking for)

- Step 1, choose what latency you want (final, rapid, ultra rapid)
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The screenshot shows a web browser window with the URL geodesy.unr.edu. The page features a header image of a geodetic station with the text "Nevada Geodetic Laboratory". Below the header is a navigation menu with links: Home, Browse Global Station List, Browse Rapid Station List, Browse Ultra Rapid Station List, Map Browse, and Acknowledgements. The main content area is titled "List of All GPS Stations Processed by NGL" and contains a grid of station identifiers.

List of All GPS Stations Processed by NGL									
00NA	01NA	02NA	1LSU	1NSU	1SAL	1ULM	20NA	21NA	25MA
299C	2TRY	3ARO	3CAN	3RIV	3RV2	4ACA	4CDA	4COO	4CRN
4CRY	4GLD	4GRM	4GWI	4HLN	4HVB	4JON	4MBH	4MC0	4MCK
4MCY	4VIR	4WCK	4YAT	59WE	5LIT	5MEN	5PTS	5YOR	7OAK
7ODM	8KUK	A351	A368	A770	AA03	AA09	AACH	AACR	AARS
AASI	AAUC	AB01	AB02	AB04	AB06	AB07	AB08	AB09	AB11
AB12	AB13	AB14	AB15	AB17	AB18	AB21	AB22	AB25	AB27
AB28	AB33	AB35	AB36	AB37	AB39	AB41	AB42	AB43	AB44
AB45	AB46	AB48	AB49	AB50	AB51	AB53	ABAN	ABAR	ABBZ
ABCC	ABD0	ABE1	ABED	ABEP	ABER	ABGS	ABIU	ABL1	ABMF
ABMS	ABOO	ABPD	ABPO	ABPW	ABQ1	ABQ2	ABQ5	ABQ6	ABRA
ABRK	ABRN	ABUZ	ABVI	ABYW	AC02	AC03	AC06	AC07	AC08
AC09	AC10	AC11	AC12	AC13	AC14	AC15	AC16	AC17	AC18
AC19	AC20	AC21	AC23	AC24	AC25	AC26	AC27	AC28	AC29
AC30	AC31	AC32	AC33	AC34	AC35	AC36	AC37	AC38	AC39
AC40	AC41	AC42	AC43	AC44	AC45	AC46	AC47	AC48	AC50
AC51	AC52	AC53	AC55	AC57	AC58	AC59	AC60	AC61	AC62

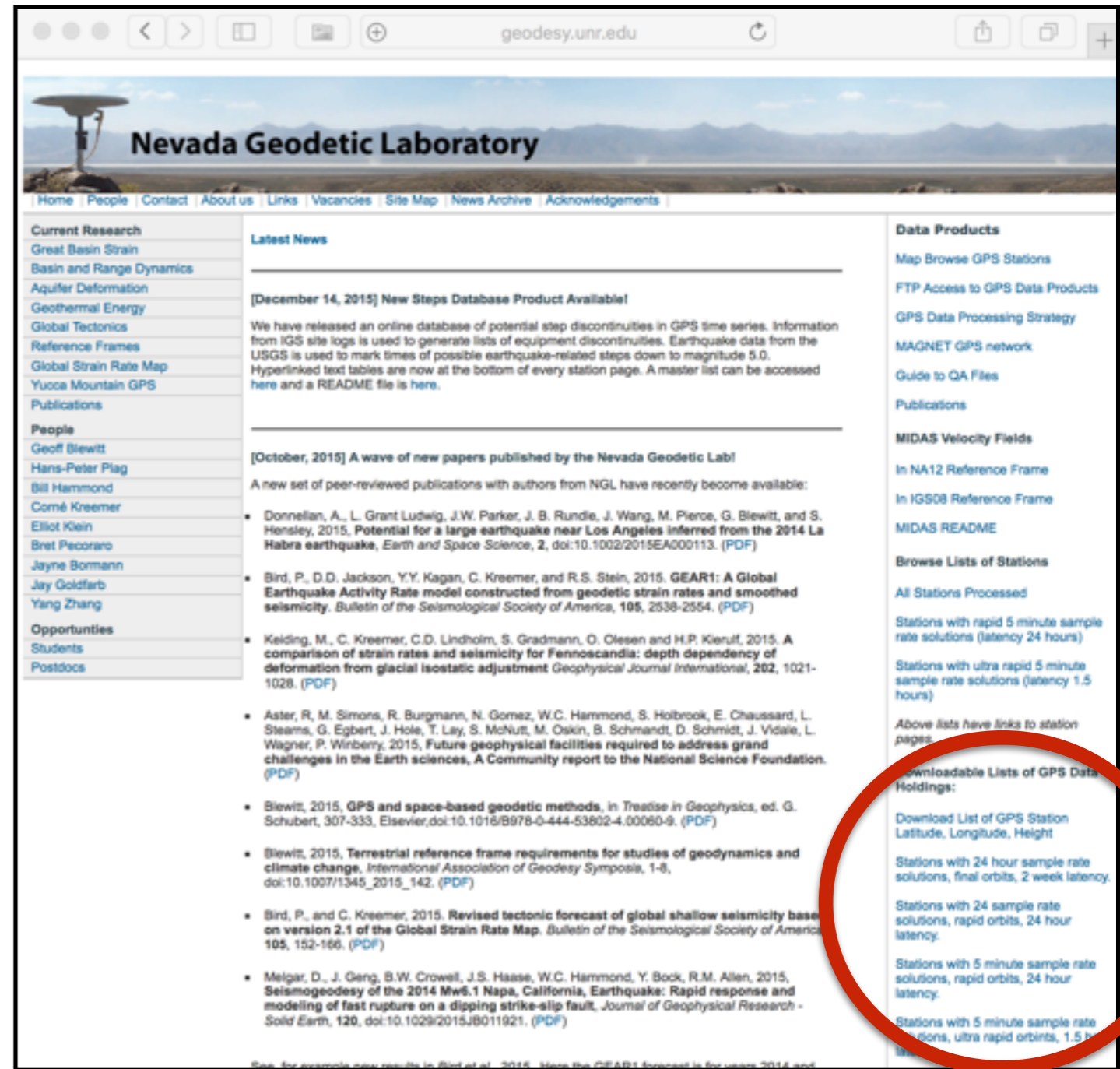
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Plug and Play Data Products: An Introduction

Online Data Holdings Files

- Follow the links from our **Data Products Area**
- Text files, updated daily
- Provide:
 - lists of stations we have
 - time span of data available
 - number of solutions
 - name translations if needed
- Separate files for
 - final 24 hour solutions
 - rapid 24 hour solutions
 - rapid 5 minute solutions
 - ultrarapid 5 minute solutions
- Why use these?
- Good for users with intermediate programming skills (e.g. good with greps and awks)



The screenshot shows the website for the Nevada Geodetic Laboratory (geodesy.unr.edu). The page features a navigation menu, a 'Current Research' sidebar, a 'Latest News' section with several articles, and a 'Data Products' sidebar. A red circle highlights the 'Downloadable Lists of GPS Data Holdings' section in the 'Data Products' sidebar, which includes links for 'Download List of GPS Station Latitude, Longitude, Height', 'Stations with 24 hour sample rate solutions, final orbits, 2 week latency', 'Stations with 24 sample rate solutions, rapid orbits, 24 hour latency', 'Stations with 5 minute sample rate solutions, rapid orbits, 24 hour latency', and 'Stations with 5 minute sample rate solutions, ultra rapid orbits, 1.5 h latency'.

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- Why use these?
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Sta	Lat(deg)	Long(deg)	Hgt(m)	X(m)	Y(m)	Z(m)	Dtbegin	Dtend	Dtmod	NumSol
00NA	-12.4666	130.8440	104.851	-4073662.2759	4712064.7454	-1367874.5096	2008-03-27	2015-12-26	2016-01-02	2353
01NA	-12.4782	130.9820	105.409	-4084823.4607	4702026.6696	-1369125.8893	2008-04-08	2013-08-12	2016-01-02	1490
02NA	-12.3559	130.8817	117.652	-4078496.4388	4711380.1446	-1355915.1775	2008-09-22	2015-10-27	2016-01-02	1832
1LSU	30.4074	268.8197	-6.487	-113402.8795	-5504361.3939	3209404.2335	2003-04-23	2015-12-26	2016-01-02	4133
1NSU	31.7508	266.9024	28.071	-293349.5323	-5420742.3561	3336980.8353	2004-01-16	2015-12-26	2016-01-02	3923
1SAL	45.4307	12.3365	55.417	4380125.6096	957947.7600	4521107.9743	2014-05-07	2015-02-28	2016-01-02	286
1ULM	32.5290	267.9241	16.000	-194982.0141	-5379221.9515	3410046.8330	2003-06-14	2015-12-26	2016-01-02	4401
20NA	-23.6982	133.8828	607.104	-4050985.3235	4212133.8047	-2547954.8558	2008-03-27	2015-12-26	2016-01-02	2323
21NA	-23.7670	133.8792	574.465	-4048578.9259	4210151.5116	-2554917.6312	2008-03-27	2015-12-26	2016-01-02	2784
25MA	-37.7719	292.2844	373.960	1914328.6149	-4671229.9504	-3885692.6988	2013-05-16	2015-12-26	2016-01-02	879
299C	64.0289	217.9242	748.177	-2209505.8339	-1721554.0061	5711800.4157	2003-01-12	2007-02-01	2016-01-02	1407
2TRY	-33.7688	151.1163	80.592	-4647366.8544	2563755.9267	-3525201.4906	2012-01-18	2013-08-28	2016-01-02	564
3ARO	-38.3821	299.7258	137.523	2482376.5130	-4347528.1128	-3938861.9538	2013-06-12	2015-12-26	2016-01-02	901
3CAN	40.6136	356.2984	765.697	4839099.9866	-313069.2588	4130439.8138	2009-01-01	2015-11-30	2016-01-02	2266
3RIV	46.3148	287.4239	-21.729	1321445.8498	-4210578.8551	4589466.7540	2000-06-17	2010-07-30	2016-01-02	18
3RV2	46.3159	287.4266	-21.491	1321618.2733	-4210427.8787	4589555.3483	2010-07-14	2010-07-29	2016-01-02	3
4ACA	-27.5985	153.0388	115.195	-5041777.8474	2564619.8794	-2937202.8217	2012-10-26	2015-12-26	2016-01-02	1070
4CDA	-28.2446	153.5561	52.251	-5034662.0008	2504036.9010	-3000433.8586	2012-02-28	2015-12-14	2016-01-02	1290
4COO	-27.4915	153.0501	54.718	-5047126.9955	2566080.1198	-2926661.2162	2012-10-26	2015-12-14	2016-01-02	961
4CRN	-16.9524	145.7425	90.120	-5044072.3773	3435355.2652	-1847819.7903	2012-01-18	2015-12-14	2016-01-02	1340
4CRY	-26.4161	152.9110	164.360	-5089053.9146	2602967.0896	-2820497.8496	2012-01-17	2015-12-26	2016-01-02	1307
4GLD	-23.8392	151.2446	60.365	-5117383.7865	2808126.1209	-2562025.5712	2012-02-09	2015-12-14	2016-01-02	1306
4GRM	-23.8392	151.2446	60.366	-5117383.7599	2808126.1397	-2562025.6070	2012-01-18	2012-01-30	2016-01-02	12
4GWI	-28.5465	150.3031	258.291	-4870791.3308	2777897.9296	-3029972.0152	2013-12-19	2015-12-22	2016-01-02	670
4HLN	-27.9219	153.3363	55.571	-5040064.2273	2530892.5250	-2968884.1075	2012-02-28	2015-12-14	2016-01-02	1216
4HVB	-25.2997	152.8098	73.953	-5132360.3952	2636563.4269	-2709155.0206	2012-01-18	2014-02-03	2016-01-02	661
4JON	-27.4256	151.4951	422.634	-4978876.8373	2703864.9121	-2920350.8968	2012-10-26	2015-12-26	2016-01-02	919
4MBH	-25.5344	152.7064	82.959	-5117682.1249	2640709.0562	-2732645.1780	2012-10-26	2015-12-26	2016-01-02	1044
4MCO	-26.6628	153.0334	66.302	-5083639.6601	2586514.4370	-2844904.7087	2012-02-28	2015-12-14	2016-01-02	1296
4MCK	-21.1172	149.1589	76.485	-5110746.9724	3051591.5856	-2283532.0532	2012-10-26	2013-12-18	2016-01-02	316
4MCY	-21.1172	149.1589	76.501	-5110746.9619	3051591.6087	-2283532.0881	2012-01-18	2012-10-14	2016-01-02	264
4VIR	-27.3759	153.0578	57.986	-5052736.6906	2568078.6012	-2915290.3121	2012-02-28	2012-06-24	2016-01-02	118
4WCK	-27.0471	150.9571	387.534	-4970022.8571	2759798.4273	-2883044.5298	2012-02-28	2012-03-26	2016-01-02	28
4YAT	-27.7340	153.2219	63.578	-5043687.6180	2545326.0726	-2950475.2540	2012-02-28	2012-09-03	2016-01-02	174
59WE	33.4311	247.8169	289.115	-2011877.6148	-4934117.2794	3494120.3332	2010-07-15	2014-07-30	2016-01-02	490
5LIT	-35.0507	138.8675	393.428	-3937318.5119	3438675.9905	-3642699.3035	2012-02-28	2012-03-24	2016-01-02	26
5MEN	-35.6892	139.3379	11.717	-3934072.8421	3379317.2845	-3700242.0209	2012-10-31	2014-03-18	2016-01-02	256
5PTS	36.4292	239.7350	56.523	-2589504.4956	-4437630.7531	3766647.8083	2010-05-01	2011-05-10	2016-01-02	335
5YOR	-35.0170	137.6063	24.629	-3862036.5903	3525749.6266	-3639428.7261	2014-04-28	2015-12-26	2016-01-02	521
7OAK	37.5950	245.2409	1713.278	-2119707.4227	-4596082.9515	3870967.7786	2010-10-18	2014-06-13	2016-01-02	50
7ODM	34.1164	242.9068	762.072	-2407750.8780	-4706536.7233	3557571.3926	2001-04-20	2015-12-26	2016-01-02	4094
8XUK	-33.1904	118.0840	298.306	-2515389.5459	4714082.1879	-3471808.0506	2012-10-30	2015-12-22	2016-01-02	1022
A351	-72.9081	74.9101	1907.477	489658.7125	1816031.2158	-6076059.1824	2001-01-11	2009-06-26	2016-01-02	337
A368	-74.2906	66.7922	1235.829	682780.4728	1592449.8432	-6118988.5415	2002-12-19	2010-04-03	2016-01-02	455
A770	-24.1590	151.8870	126.353	-5135893.5743	2743809.2641	-2594414.9132	2013-12-24	2015-12-26	2016-01-02	669 1770
AA03	8.3290	80.4100	-8.500	1051446.3862	6223098.7057	917795.8094	2014-09-09	2014-09-12	2016-01-02	4
AA09	5.9567	80.5446	-89.364	1042162.3213	6257649.8339	657490.9938	2014-09-08	2014-09-13	2016-01-02	6
AACH	50.7679	6.0884	263.286	4019427.7061	428731.1738	4917460.4109	2011-10-20	2011-12-23	2016-01-02	65
AACR	9.9388	275.8821	1123.929	644009.0052	-6251064.2621	1093780.8637	2013-06-02	2015-11-07	2016-01-02	635
AARS	50.9633	4.8361	104.668	4010937.4678	339354.2331	4931056.2586	2009-08-07	2015-12-17	2016-01-02	1647
AASI	68.7193	307.2067	56.282	1403876.4604	-1849092.6568	5920733.5044	2007-06-01	2008-06-14	2016-01-02	376

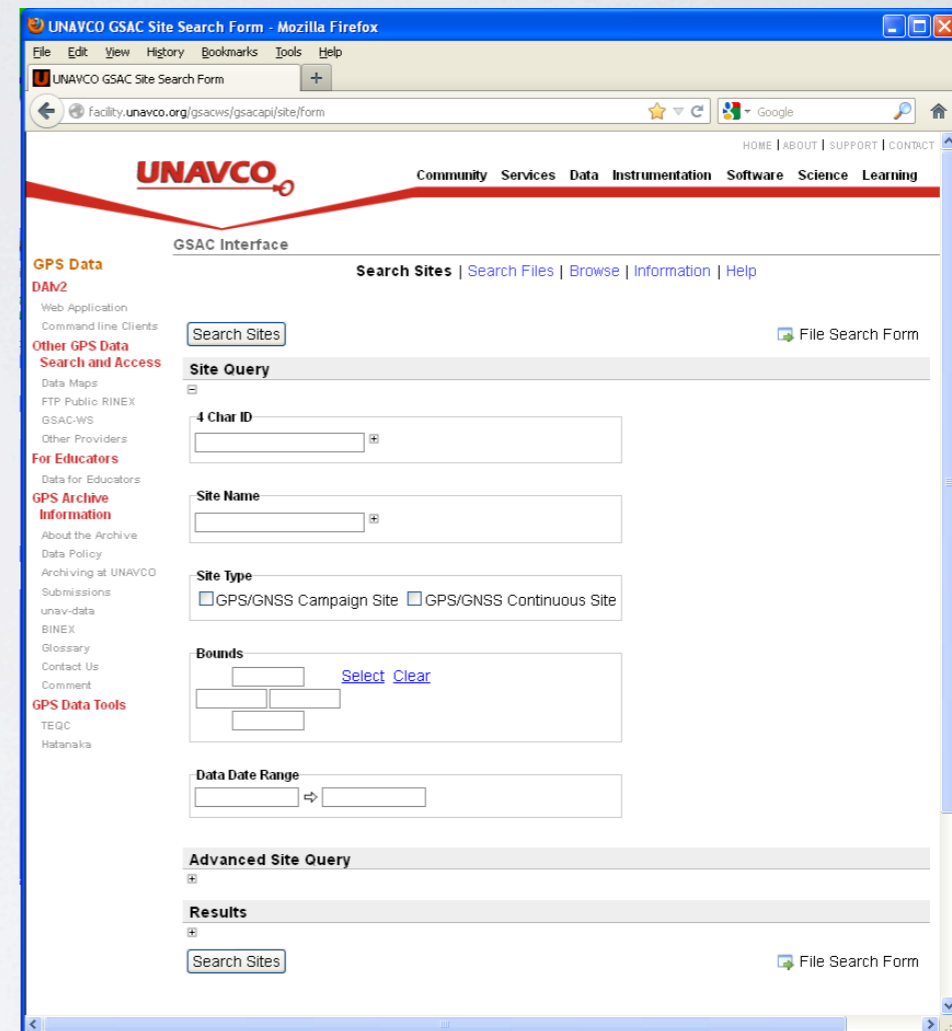
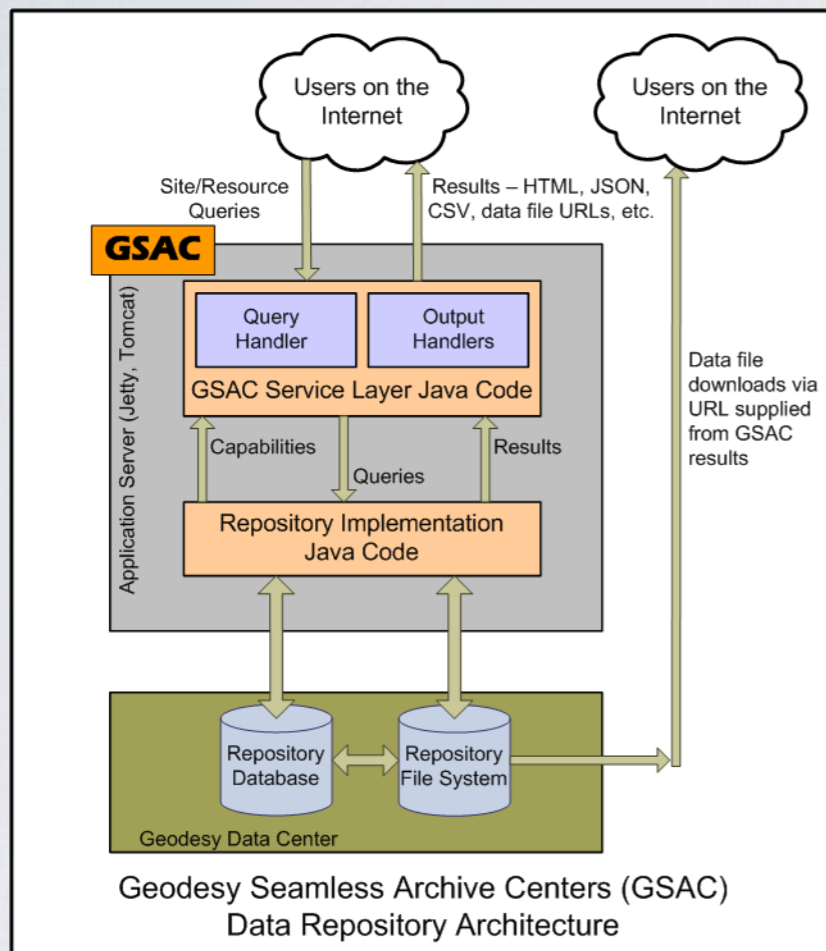
* Melgar, D., J. Geng, B.W. Crowell, J.S. Haase, W.C. Hammond, Y. Bock, R.M. Allen, 2015, Seismogeodesy of the 2014 Mw6.1 Napa, California, Earthquake: Rapid response and modeling of fast rupture on a dipping strike-slip fault, *Journal of Geophysical Research - Solid Earth*, 120, doi:10.1029/2015JB011921. (PDF)

Stations with 5 minute sample rate solutions, rapid orbits, 24 hour latency.
Stations with 5 minute sample rate solutions, ultra rapid orbits, 1.5 h latency.

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Geodesy Seamless Archive Centers (GSAC) Web Services – A Software Package for Geoscience Data Centers

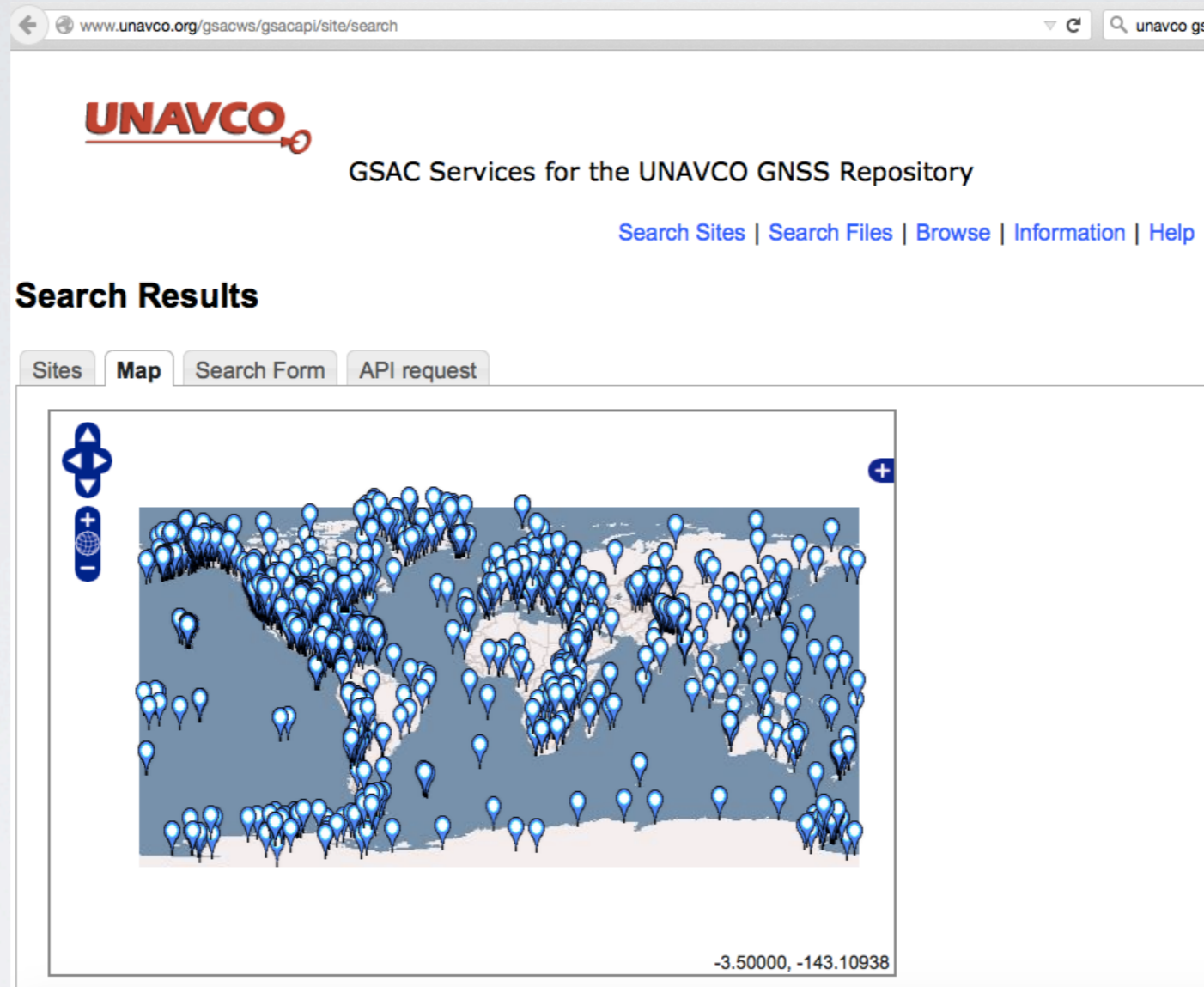


- Start with existing repository and metadata
- Small set of required metadata; any optional metadata
- Download Java code from Sourceforge project
- Simple installation and configuration

Upon installation and configuration GSAC provides:

- Web user interface
- Operating web services
- Documentation for users of web services API
- Ability to federate with other GSAC centers

Geodesy Seamless Archive Centers (GSAC) Web Services – UNAVCO Managed Repository



www.unavco.org/gsacws/gsacapi/site/search

UNAVCO

GSAC Services for the UNAVCO GNSS Repository

[Search Sites](#) | [Search Files](#) | [Browse](#) | [Information](#) | [Help](#)

Search Results

Sites | **Map** | Search Form | API request

-3.50000, -143.10938

- The UNAVCO GSAC searches the UNAVCO archives only. UNAVCO hosts data from ~3,500 stations from many countries providing continuous data

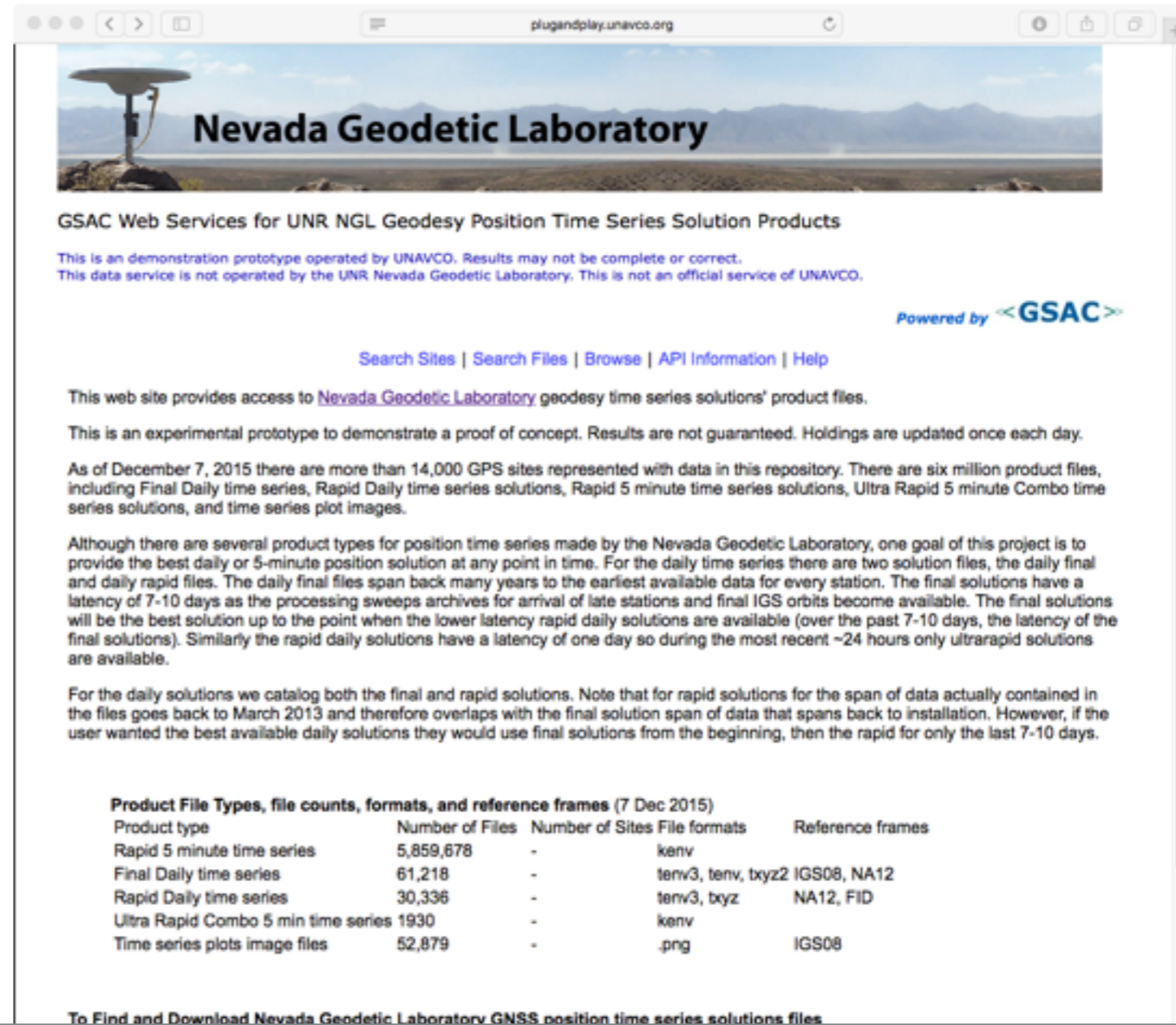
Plug and Play Data Products: An Introduction

Special GSAC Query for UNR files

<http://plugandplay.unavco.org:8080/unrgsac/gsacapi/>

Search for files including:

- Time series
- Plots (.png)
- Quality Control files
- In any latency
- In any frame
- specify sites
- specify data date ranges
- Many output options
- e.g. wget scripts for direct downloads
- Still under development



The screenshot shows the Nevada Geodetic Laboratory website. The header features a banner image of a geodetic station with the text "Nevada Geodetic Laboratory". Below the banner, the page title is "GSAC Web Services for UNR NGL Geodesy Position Time Series Solution Products". A disclaimer states: "This is an demonstration prototype operated by UNAVCO. Results may not be complete or correct. This data service is not operated by the UNR Nevada Geodetic Laboratory. This is not an official service of UNAVCO." The page is powered by GSAC, as indicated by the "Powered by <GSAC>" logo. Navigation links include "Search Sites", "Search Files", "Browse", "API Information", and "Help". The main content area provides information about the data repository, stating that as of December 7, 2015, there are more than 14,000 GPS sites represented with data in this repository, including six million product files. A table titled "Product File Types, file counts, formats, and reference frames (7 Dec 2015)" is also present.

Product type	Number of Files	Number of Sites	File formats	Reference frames
Rapid 5 minute time series	5,859,678	-	kenv	
Final Daily time series	61,218	-	tenv3, tenv, txyz2	IGS08, NA12
Rapid Daily time series	30,336	-	tenv3, txyz	NA12, FID
Ultra Rapid Combo 5 min time series	1930	-	kenv	
Time series plots image files	52,879	-	.png	IGS08

To Find and Download Nevada Geodetic Laboratory GNSS position time series solutions files

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Plug and Play Data Products: An Introduction

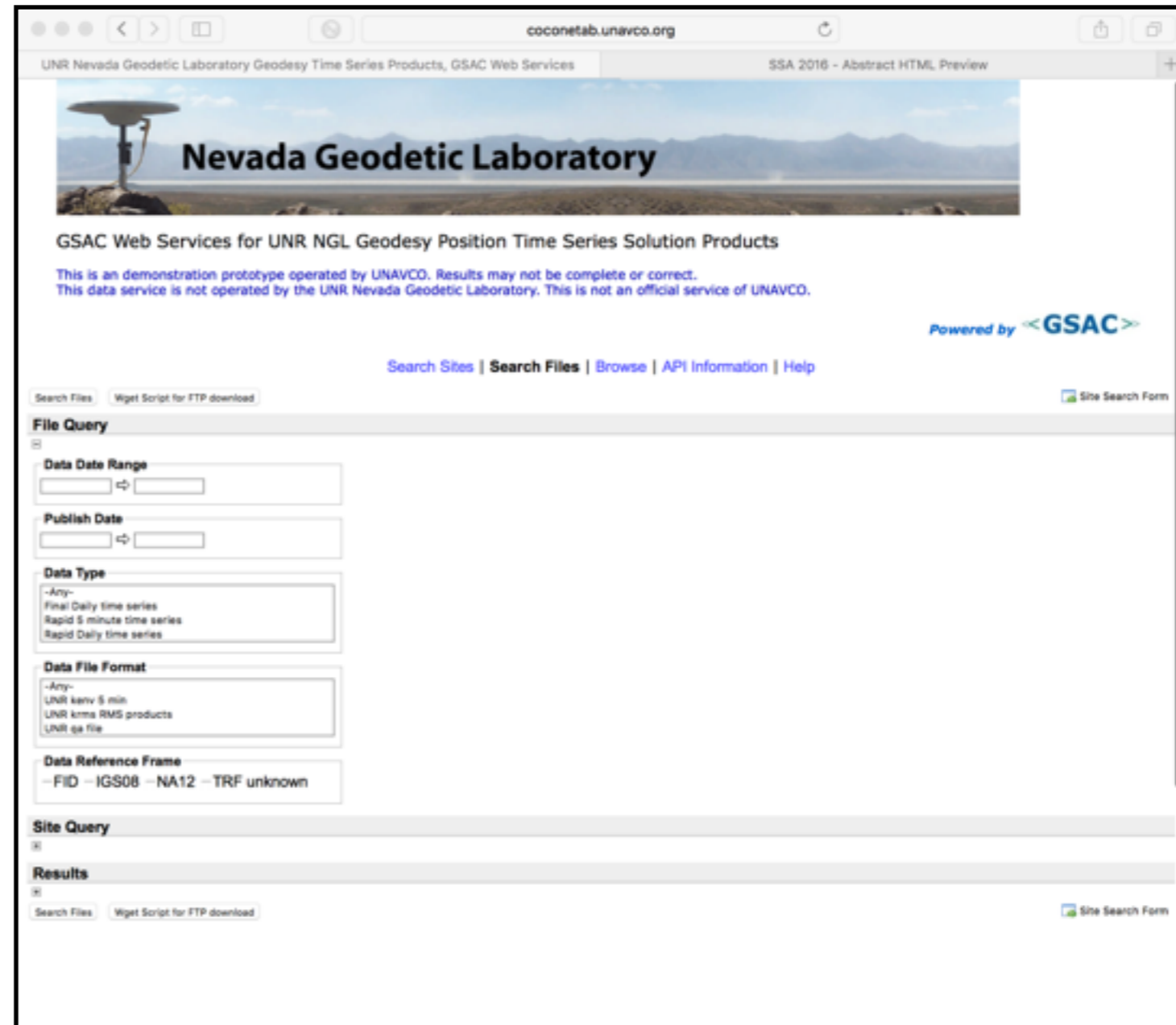
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- e.g. wget scripts for direct downloads

Still under development



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UNR data using combined final and rapid files:

[http://unagi.int.unavco.org:5000/gps/data/position/P378/v2?](http://unagi.int.unavco.org:5000/gps/data/position/P378/v2?referenceFrame=igs08&analysisCenter=unr&starttime=2015-11-30T00:00:00&endtime=2015-12-02T00:00:00&tsFormat=iso8601&report=long)

[referenceFrame=igs08&analysisCenter=unr&starttime=2015-11-30T00:00:00&endtime=2015-12-02T00:00:00&tsFormat=iso8601&report=long](http://unagi.int.unavco.org:5000/gps/data/position/P378/v2?referenceFrame=igs08&analysisCenter=unr&starttime=2015-11-30T00:00:00&endtime=2015-12-02T00:00:00&tsFormat=iso8601&report=long)

```
# fields: DateTime, X, Y, Z, X Std. Dev, Y Std. Dev, Z Std. Dev, XY Correlation, XZ Correlation, YZ Correlation, North
Latitude, East Longitude, Height, North, East, Vertical, North Std. Dev.(m), East Std. Dev.(m), Vertical Std. Dev.(m),
NorthEast Correlation, NorthVertical Correlation, EastVertical Correlation, Solution
# field_unit: ISO 8601 datetime UTC, meters, meters, meters, millimeters, millimeters, millimeters, number, number,
degrees, degrees, meters, meters, meters, meters, meters, meters, meters, number, number, number, UTF-8
# field_type: string, float, float, float, float, float, float, float, float, float, float, float, float, float, float,
float, float, float, float, float, string
# attribution: http: www.unavco.org/community/policies_forms/attribution/attribution.html
# myURI: http://unagi.int.unavco.org:5000/gps/data/position/P378/v2?
referenceFrame=igs08&analysisCenter=unr&starttime=2015-11-30T00:00:00&endtime=2015-12-02T00:00:00&tsFormat=iso8601&report=long
# XYZ Reference Coordinate: x: -2475699.7712 y: -3822330.29648 z: 4450718.27949
# Applied Offset: x: 0 y: 0 z: 0
2015-11-30T00:00:00,-2475699.869468970224261,-3822330.289946420118213,4450718.256974049843848,0.000860970301321,0.0011497148740
99,0.001277278291350,0.773765182532420,-0.769955989181483,-0.701141881563536,44.534981963033061,-122.930882522434459,83.1209957
33886957,-49.6688164866,-86.0351683839,18.3794425503,0.4624840289,0.6436160957,1.7511198786,-247.6263002044,-173.2377149944,-77
.5286091769,rapid
2015-12-01T00:00:00,-2475699.868869829922915,-3822330.288743469864130,4450718.255798240192235,0.000875976771472,0.0011700849172
12,0.001274559446847,0.779128063274658,-0.771200678588542,-0.707302465449681,44.534981963918717,-122.930882524335260,83.1192191
97891653,-49.5704001640,-86.1862498952,16.6029079022,0.4652102570,0.6454525118,1.7685887801,-232.8672141550,-172.2778330665,-11
0.1741539511,rapid
```

Velocity Fields

- MIDAS... what is it?
- How to get it.
- Caveats

MIDAS: A New Paradigm

A blue square containing a white outline of the letter 'N'.

MIDAS: Robust Trend Estimator for Accurate GPS Station Velocities Without Step Detection

Geoff Blewitt

Nevada Geodetic Laboratory
University of Nevada, Reno, USA

co-authors:

Corné Kreemer, Bill Hammond, and Julien Gazeaux

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Robust Velocity Estimator (MIDAS): Median temporal filtering

- MIDAS is based on Theil-Sen (1950), with the following innovations:

- 1) Median difference of solutions 365 days apart

$$\hat{v} = \text{median}_i (x_{i+365} - x_i)$$

- insensitive to seasonality AND steps

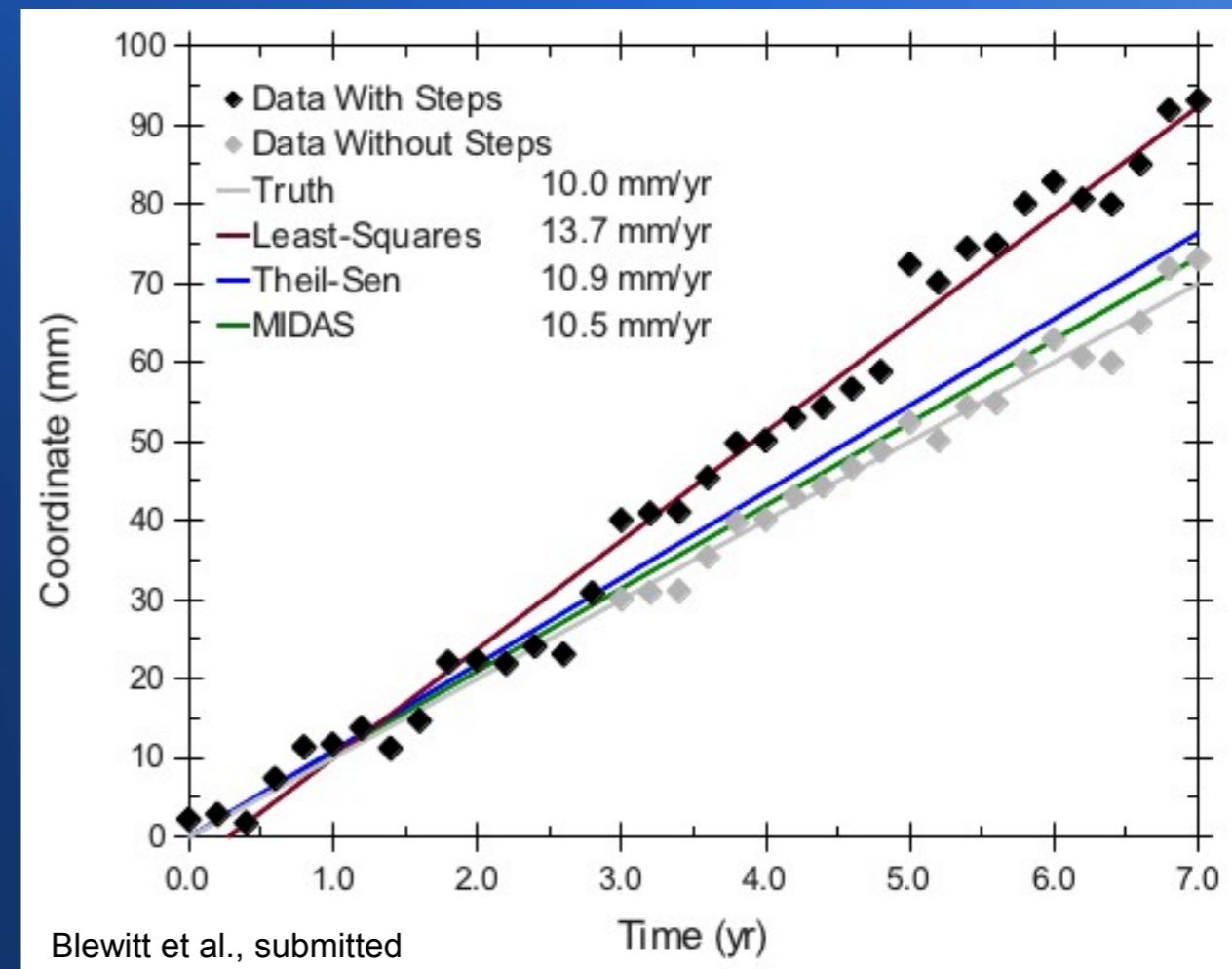
- 2) Robust estimate of standard deviation

$$\sigma = 1.4826 \text{ median}_i |x_{i+365} - x_i - \hat{v}|$$

- 3) Remove 2-sigma tails and recompute median

- 4) Compute MIDAS velocity uncertainty

$$\sigma_v = 1.2533 \frac{\sigma}{\sqrt{N/4}}$$

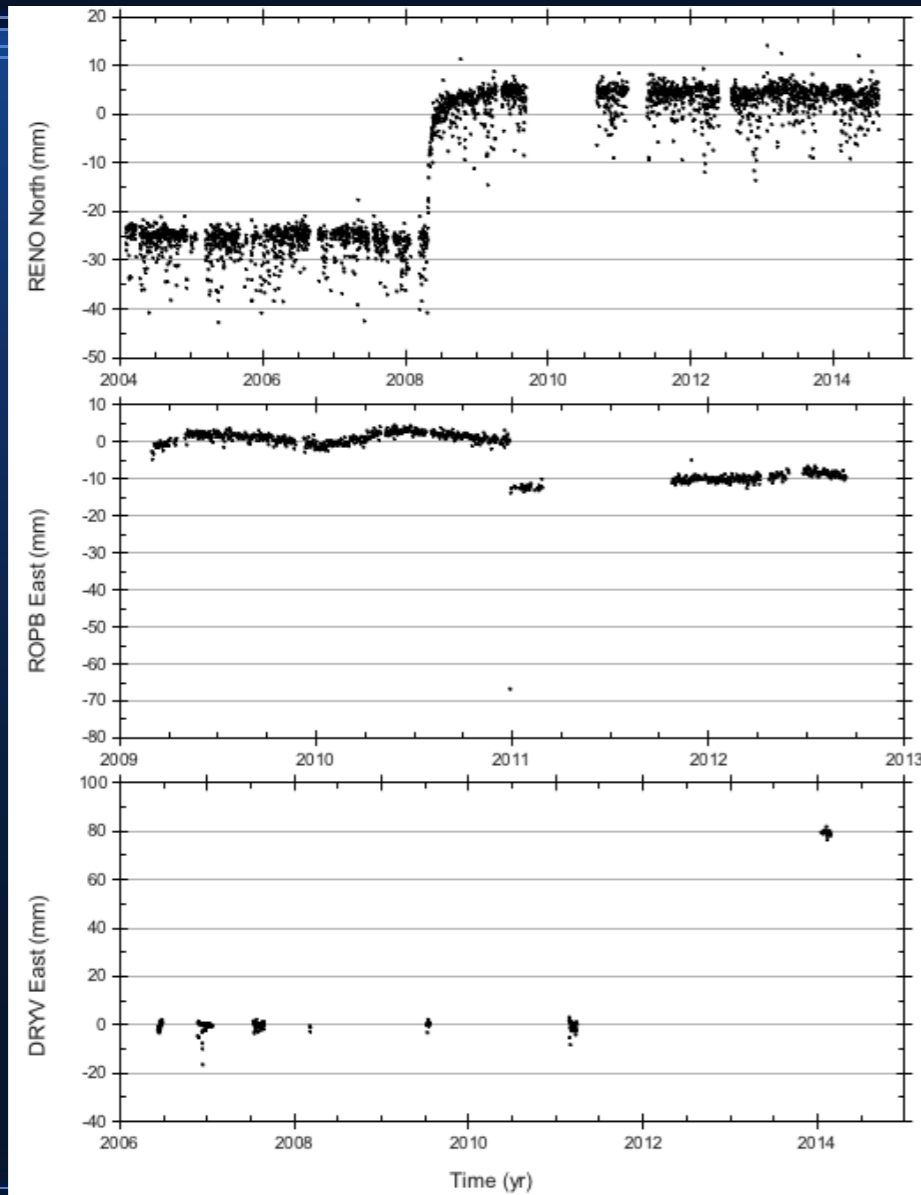


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MIDAS (median temporal filter) velocity is insensitive to steps



- **Detrended time series**

- Station affected by M_w 5.0 earthquake 2008/04/26

- Station with undocumented equipment change

- Campaign station monument vandalized and replaced

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MIDAS SUMMARY



Key Points on MIDAS

- Automatic, non-parametric estimator of time-series trend
- GPS velocities are robust to outliers, steps, and seasonality
- Velocities are the most accurate of all automatic methods tested

Operations

- MIDAS velocities now updated weekly > 13,700 stations

Open Access

- Make MIDAS JGR paper freely available
- Make MIDAS velocities public
- Make MIDAS software public

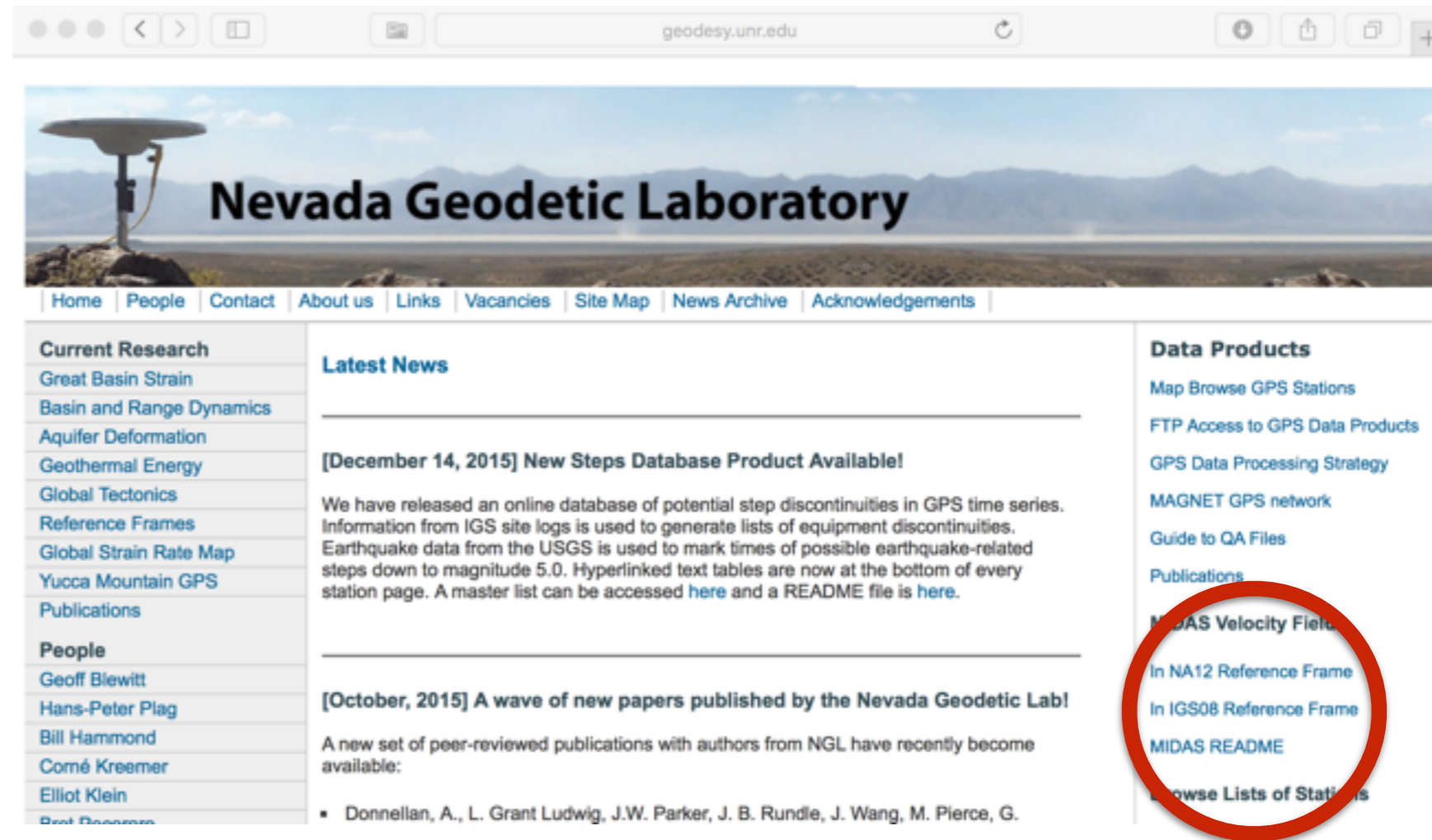
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Plug and Play Data Products: An Introduction

MIDAS velocity field

How to get it

- Go to NGL Data products
- Hit the link...
- Consult the README for column definitions



The screenshot shows the website for the Nevada Geodetic Laboratory (geodesy.unr.edu). The page features a navigation menu with links like Home, People, Contact, About us, Links, Vacancies, Site Map, News Archive, and Acknowledgements. There are three main content areas: Current Research, Latest News, and Data Products. The Data Products section includes links for Map Browse GPS Stations, FTP Access to GPS Data Products, GPS Data Processing Strategy, MAGNET GPS network, Guide to QA Files, Publications, MIDAS Velocity Field (circled in red), In NA12 Reference Frame, In IGS08 Reference Frame, MIDAS README, and Browse Lists of Stations. The Latest News section contains two entries: one from December 14, 2015, about a new database product, and one from October 2015 about new publications.

Also soon to appear as an option on the UNAVCO velocity field plotter:

<https://www.unavco.org/software/visualization/GPS-Velocity-Viewer/GPS-Velocity-Viewer.html>

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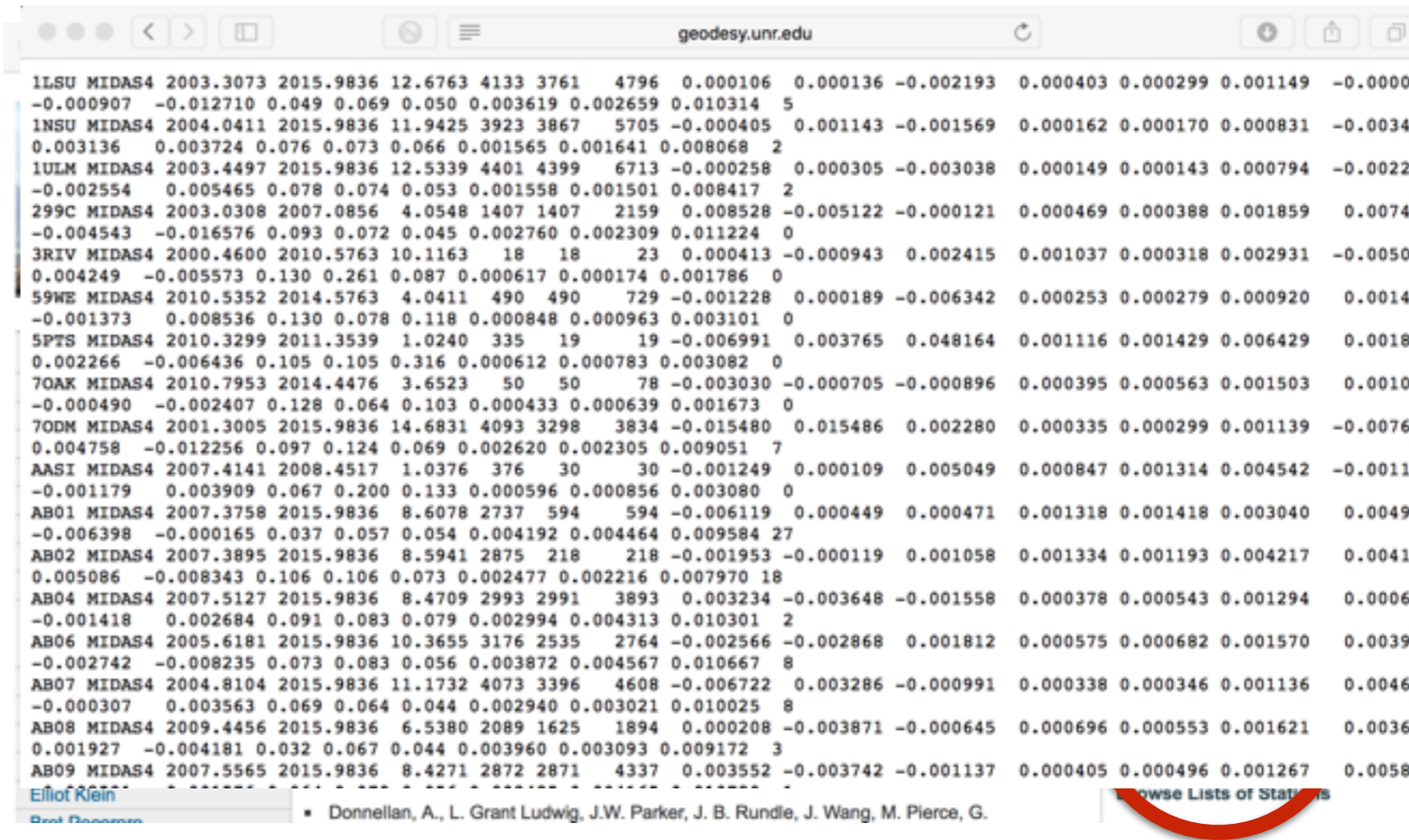


Plug and Play Data Products: An Introduction

MIDAS velocity field

How to get it

- Go to NGL Data products
- Hit the link...
- Consult the README for column definitions



ILSU MIDAS4	2003.3073	2015.9836	12.6763	4133	3761	4796	0.000106	0.000136	-0.002193	0.000403	0.000299	0.001149	-0.0000
-0.000907	-0.012710	0.049	0.069	0.050	0.003619	0.002659	0.010314	5					
1NSU MIDAS4	2004.0411	2015.9836	11.9425	3923	3867	5705	-0.000405	0.001143	-0.001569	0.000162	0.000170	0.000831	-0.0034
0.003136	0.003724	0.076	0.073	0.066	0.001565	0.001641	0.008068	2					
1ULM MIDAS4	2003.4497	2015.9836	12.5339	4401	4399	6713	-0.000258	0.000305	-0.003038	0.000149	0.000143	0.000794	-0.0022
-0.002554	0.005465	0.078	0.074	0.053	0.001558	0.001501	0.008417	2					
299C MIDAS4	2003.0308	2007.0856	4.0548	1407	1407	2159	0.008528	-0.005122	-0.000121	0.000469	0.000388	0.001859	0.0074
-0.004543	-0.016576	0.093	0.072	0.045	0.002760	0.002309	0.011224	0					
3RIV MIDAS4	2000.4600	2010.5763	10.1163	18	18	23	0.000413	-0.000943	0.002415	0.001037	0.000318	0.002931	-0.0050
0.004249	-0.005573	0.130	0.261	0.087	0.000617	0.000174	0.001786	0					
59WE MIDAS4	2010.5352	2014.5763	4.0411	490	490	729	-0.001228	0.000189	-0.006342	0.000253	0.000279	0.000920	0.0014
-0.001373	0.008536	0.130	0.078	0.118	0.000848	0.000963	0.003101	0					
5PTS MIDAS4	2010.3299	2011.3539	1.0240	335	19	19	-0.006991	0.003765	0.048164	0.001116	0.001429	0.006429	0.0018
0.002266	-0.006436	0.105	0.105	0.316	0.000612	0.000783	0.003082	0					
7OAK MIDAS4	2010.7953	2014.4476	3.6523	50	50	78	-0.003030	-0.000705	-0.000896	0.000395	0.000563	0.001503	0.0010
-0.000490	-0.002407	0.128	0.064	0.103	0.000433	0.000639	0.001673	0					
7ODM MIDAS4	2001.3005	2015.9836	14.6831	4093	3298	3834	-0.015480	0.015486	0.002280	0.000335	0.000299	0.001139	-0.0076
0.004758	-0.012256	0.097	0.124	0.069	0.002620	0.002305	0.009051	7					
AASI MIDAS4	2007.4141	2008.4517	1.0376	376	30	30	-0.001249	0.000109	0.005049	0.000847	0.001314	0.004542	-0.0011
-0.001179	0.003909	0.067	0.200	0.133	0.000596	0.000856	0.003080	0					
AB01 MIDAS4	2007.3758	2015.9836	8.6078	2737	594	594	-0.006119	0.000449	0.000471	0.001318	0.001418	0.003040	0.0049
-0.006398	-0.000165	0.037	0.057	0.054	0.004192	0.004464	0.009584	27					
AB02 MIDAS4	2007.3895	2015.9836	8.5941	2875	218	218	-0.001953	-0.000119	0.001058	0.001334	0.001193	0.004217	0.0041
0.005086	-0.008343	0.106	0.106	0.073	0.002477	0.002216	0.007970	18					
AB04 MIDAS4	2007.5127	2015.9836	8.4709	2993	2991	3893	0.003234	-0.003648	-0.001558	0.000378	0.000543	0.001294	0.0006
-0.001418	0.002684	0.091	0.083	0.079	0.002994	0.004313	0.010301	2					
AB06 MIDAS4	2005.6181	2015.9836	10.3655	3176	2535	2764	-0.002566	-0.002868	0.001812	0.000575	0.000682	0.001570	0.0039
-0.002742	-0.008235	0.073	0.083	0.056	0.003872	0.004567	0.010667	8					
AB07 MIDAS4	2004.8104	2015.9836	11.1732	4073	3396	4608	-0.006722	0.003286	-0.000991	0.000338	0.000346	0.001136	0.0046
-0.000307	0.003563	0.069	0.064	0.044	0.002940	0.003021	0.010025	8					
AB08 MIDAS4	2009.4456	2015.9836	6.5380	2089	1625	1894	0.000208	-0.003871	-0.000645	0.000696	0.000553	0.001621	0.0036
0.001927	-0.004181	0.032	0.067	0.044	0.003960	0.003093	0.009172	3					
AB09 MIDAS4	2007.5565	2015.9836	8.4271	2872	2871	4337	0.003552	-0.003742	-0.001137	0.000405	0.000496	0.001267	0.0058

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<https://www.unavco.org/software/visualization/GPS-Velocity-Viewer/GPS-Velocity-Viewer.html>

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MIDAS Properties and Caveats

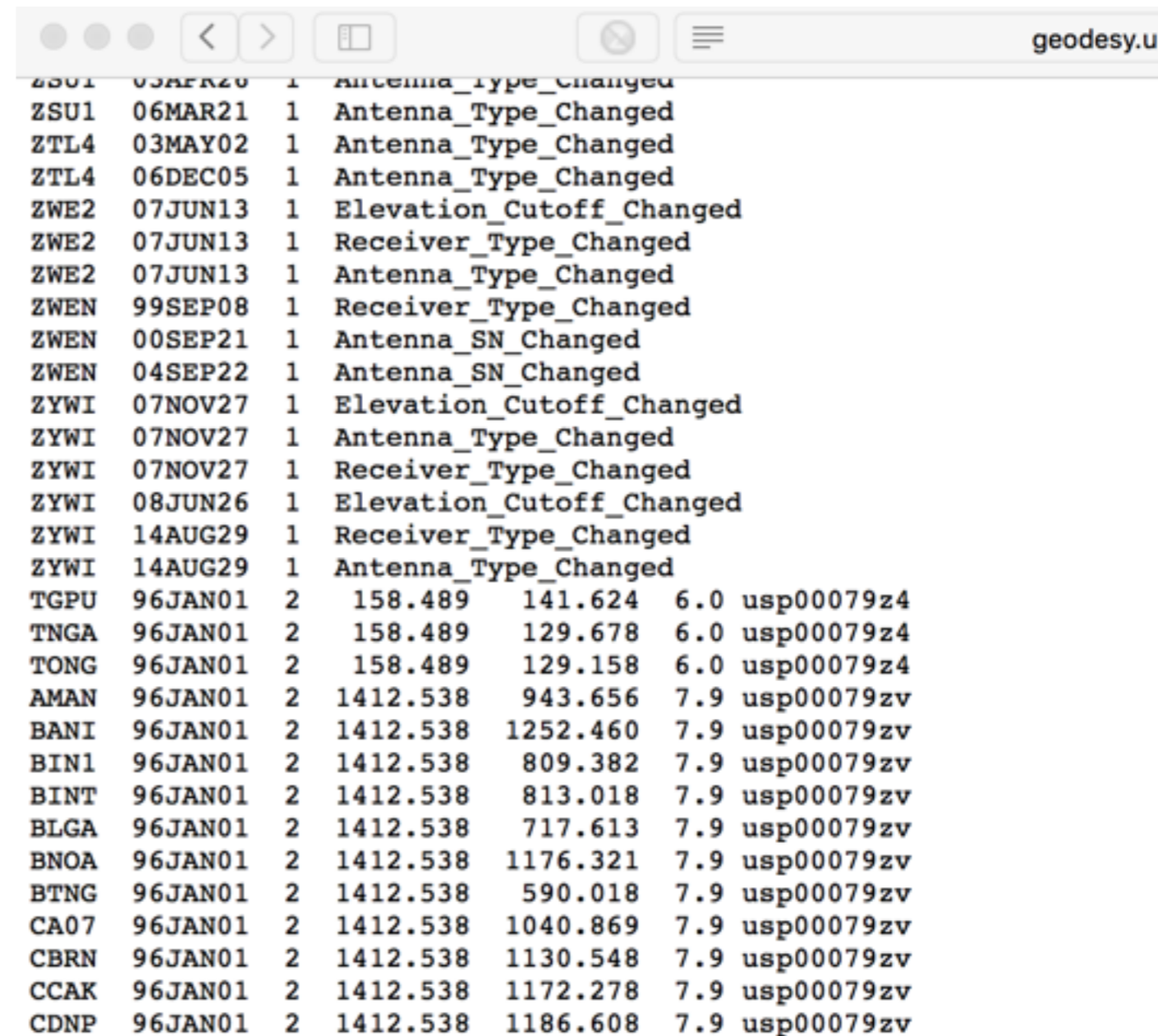
- Available in IGS08 and NA12 frames only right now
- Applied to all time series over 1 year in duration
- Automatically generated. No hands on review.
- Steps and outliers ignored.
- If time series is non-linear, median-based algorithm picks one velocity (the mode)
- Does not necessarily represent strain accumulation part of seismic cycle only.

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Steps and Discontinuities Database

- Earthquakes and equipment change events often cause discontinuities in time series.
- Important to know when these occur
- Get our list of known events from our Data Products section of <http://geodesy.unr.edu>
- Marked for equipment if change of antenna, receiver, radome in log file.
- Earthquake marked if epicenter is with distance function of magnitude from station
- Links to USGS event page provided
- Also see tables specific for each station at the bottom of each Station Page



The screenshot shows a web browser window with the URL 'geodesy.u' in the address bar. The browser displays a table of station events. The table has columns for station ID, date, count, event description, and coordinates. The events are categorized into equipment changes and earthquakes.

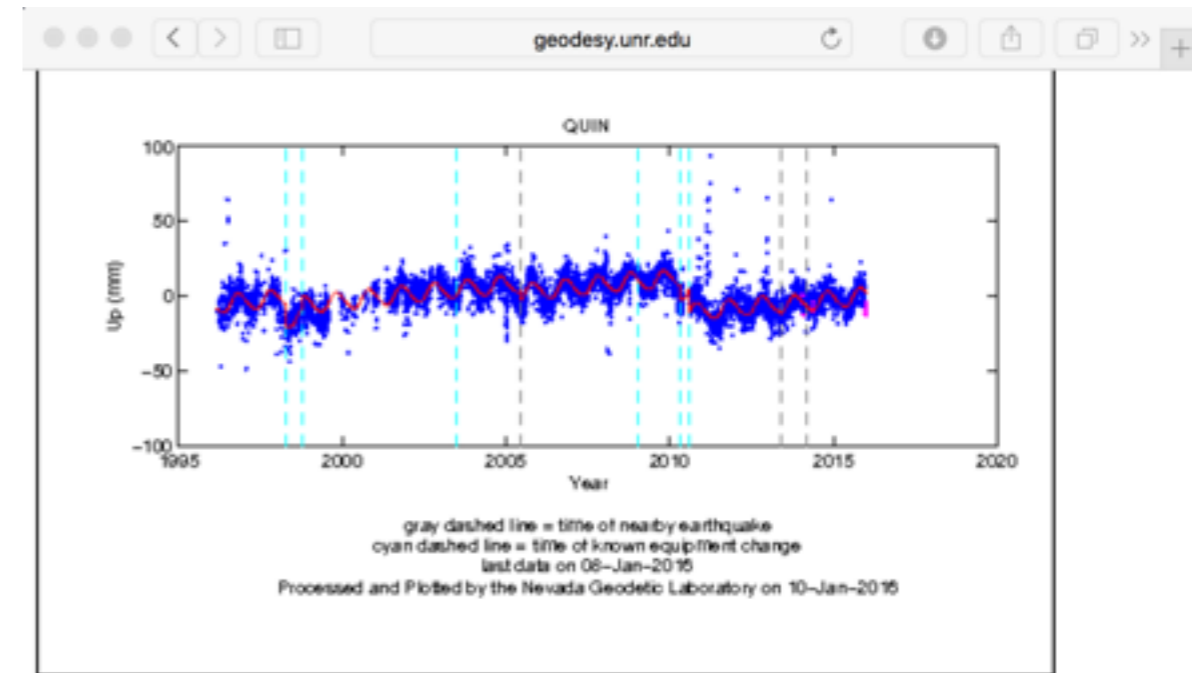
Station	Date	Count	Event Description	Coordinates
ZSU1	03APR20	1	Antenna_Type_Changed	
ZSU1	06MAR21	1	Antenna_Type_Changed	
ZTL4	03MAY02	1	Antenna_Type_Changed	
ZTL4	06DEC05	1	Antenna_Type_Changed	
ZWE2	07JUN13	1	Elevation_Cutoff_Changed	
ZWE2	07JUN13	1	Receiver_Type_Changed	
ZWE2	07JUN13	1	Antenna_Type_Changed	
ZWEN	99SEP08	1	Receiver_Type_Changed	
ZWEN	00SEP21	1	Antenna_SN_Changed	
ZWEN	04SEP22	1	Antenna_SN_Changed	
ZYWI	07NOV27	1	Elevation_Cutoff_Changed	
ZYWI	07NOV27	1	Antenna_Type_Changed	
ZYWI	07NOV27	1	Receiver_Type_Changed	
ZYWI	08JUN26	1	Elevation_Cutoff_Changed	
ZYWI	14AUG29	1	Receiver_Type_Changed	
ZYWI	14AUG29	1	Antenna_Type_Changed	
TGPU	96JAN01	2	158.489 141.624 6.0	usp00079z4
TNGA	96JAN01	2	158.489 129.678 6.0	usp00079z4
TONG	96JAN01	2	158.489 129.158 6.0	usp00079z4
AMAN	96JAN01	2	1412.538 943.656 7.9	usp00079zv
BANI	96JAN01	2	1412.538 1252.460 7.9	usp00079zv
BIN1	96JAN01	2	1412.538 809.382 7.9	usp00079zv
BINT	96JAN01	2	1412.538 813.018 7.9	usp00079zv
BLGA	96JAN01	2	1412.538 717.613 7.9	usp00079zv
BNOA	96JAN01	2	1412.538 1176.321 7.9	usp00079zv
BTNG	96JAN01	2	1412.538 590.018 7.9	usp00079zv
CA07	96JAN01	2	1412.538 1040.869 7.9	usp00079zv
CBRN	96JAN01	2	1412.538 1130.548 7.9	usp00079zv
CCAK	96JAN01	2	1412.538 1172.278 7.9	usp00079zv
CDNP	96JAN01	2	1412.538 1186.608 7.9	usp00079zv

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- Marked for equipment if change of antenna, receiver, radome in log file.
- Earthquake marked if epicenter is with distance function of magnitude from station
- Links to USGS event page provided
- Also see tables specific for each station at the bottom of each Station Page



Steps Information for this station

Station ID	Date (YYMMDD)	Code	Type/EventID
QUIN	98APR01	1	Antenna_SN_Changed
QUIN	98OCT13	1	Antenna_SN_Changed
QUIN	03JUL09	1	Receiver_Type_Changed
QUIN	09JAN15	1	Antenna_Type_Changed
QUIN	10MAY07	1	Radome_Changed
QUIN	10AUG12	1	Radome_Changed
QUIN	05JUN15	2	iscgem7143782
QUIN	13MAY24	2	nc71996906
QUIN	14MAR10	2	nc72182046

Code=1 is time of an equipment change from IGS log file (antenna, receiver or firmware change)
Code=2 is possible earthquake step where epicenter is within $10^{(0.5 \cdot \text{mag} - 0.8)}$ degrees of station
[Link to full steps file for all stations.](#)



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Products Coming Soon (some Imminent, some Aspirational)

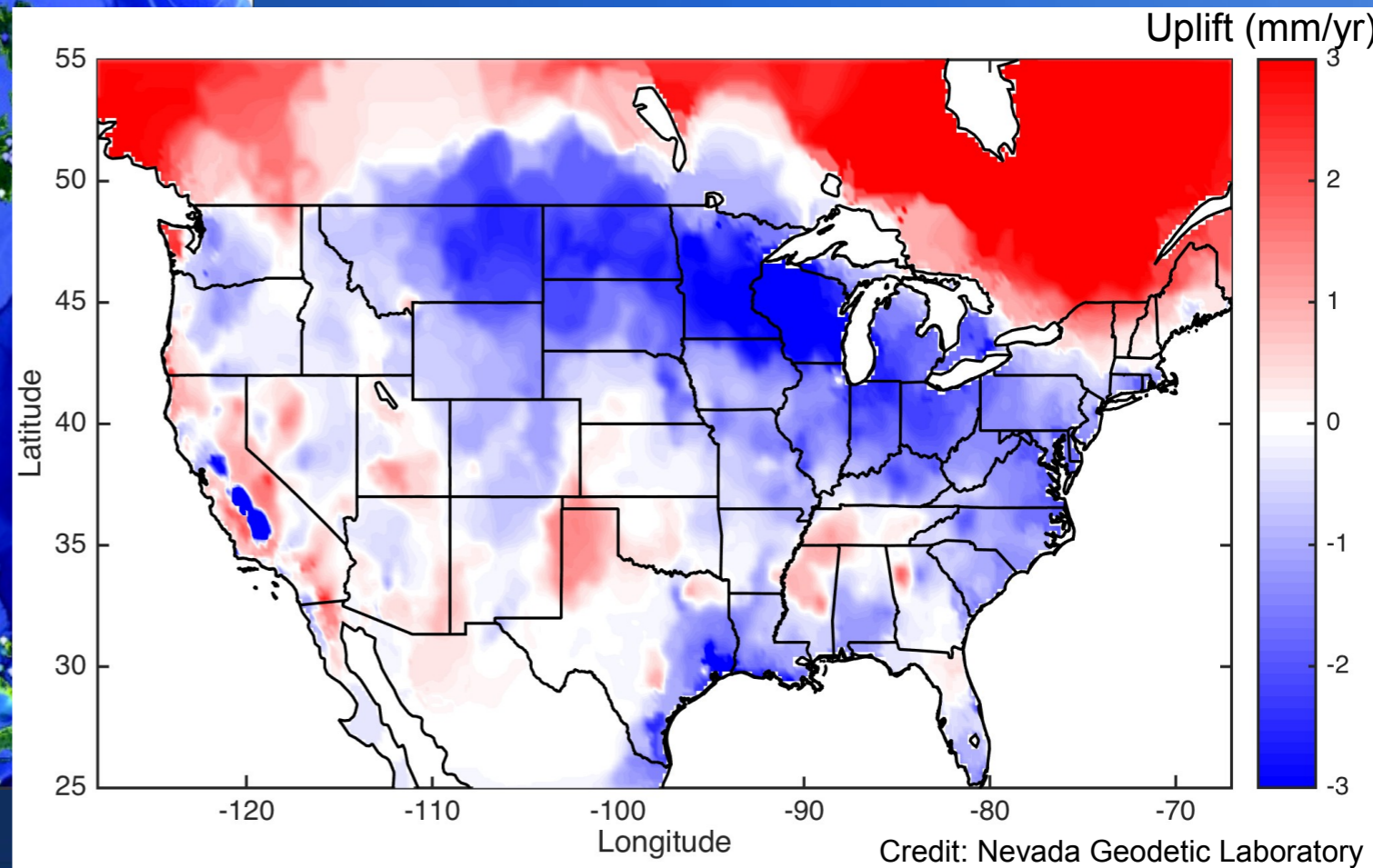
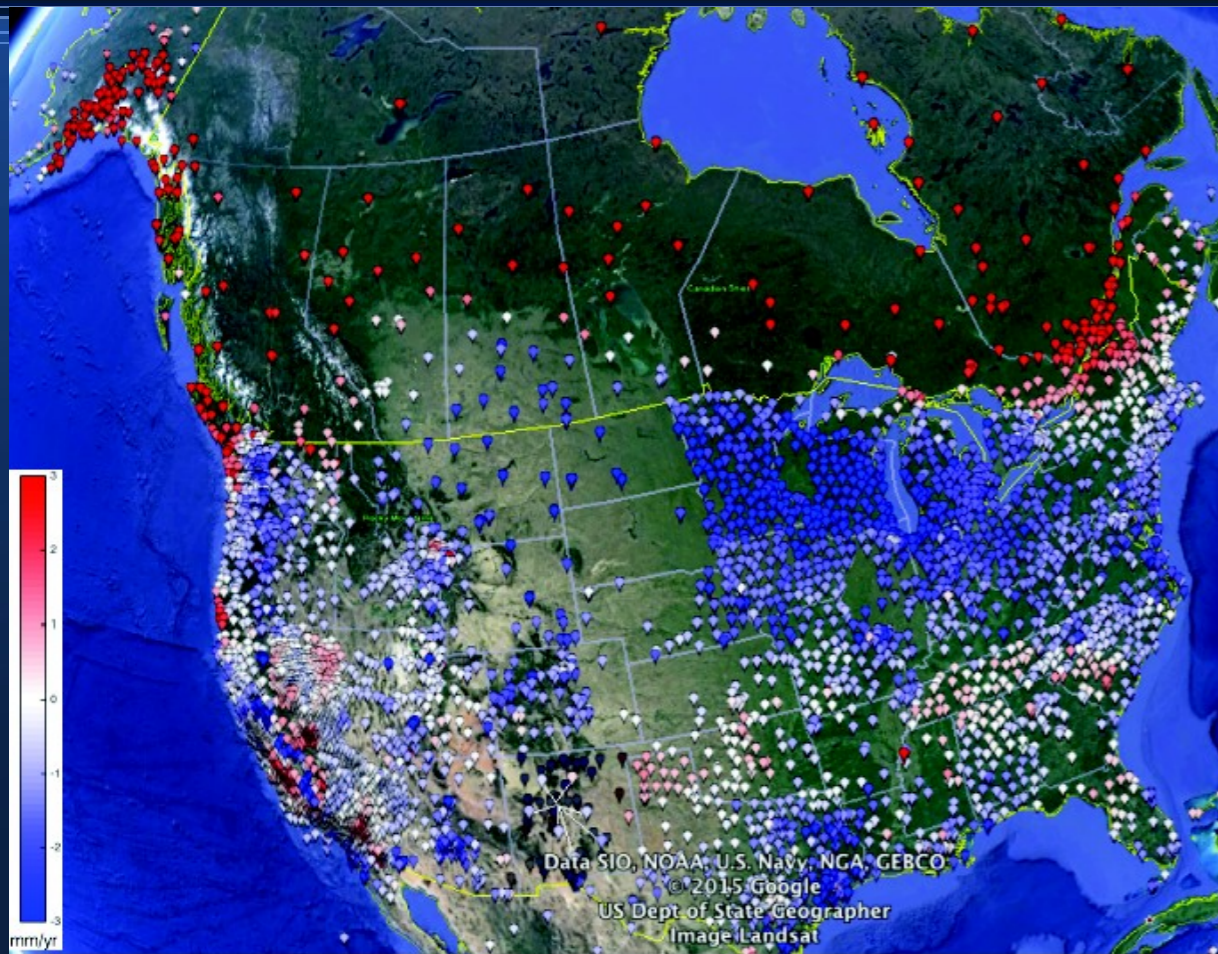
- More reference frames for existing products: e.g. tectonic plate based frames for Africa, South America, Eurasia, Pacific
- Median spatial filtered velocities
- Uplift Maps based on GPS imaging (flat maps and .kml)
- Better time series plotting tools
- Strain rate maps
- Earthquake offset pages, put out with lowest possible latencies

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GPS data can now be used to image uplift.

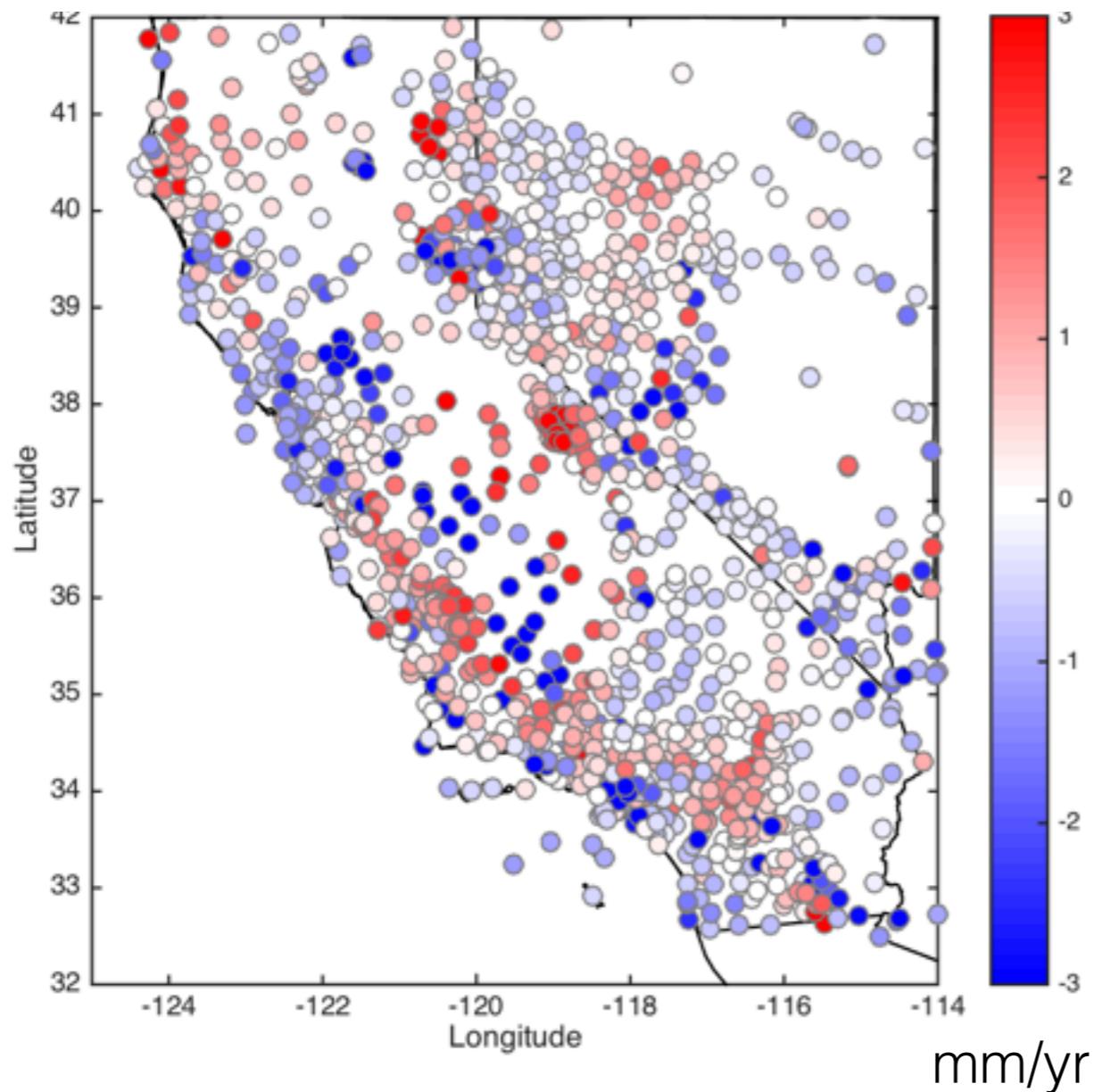


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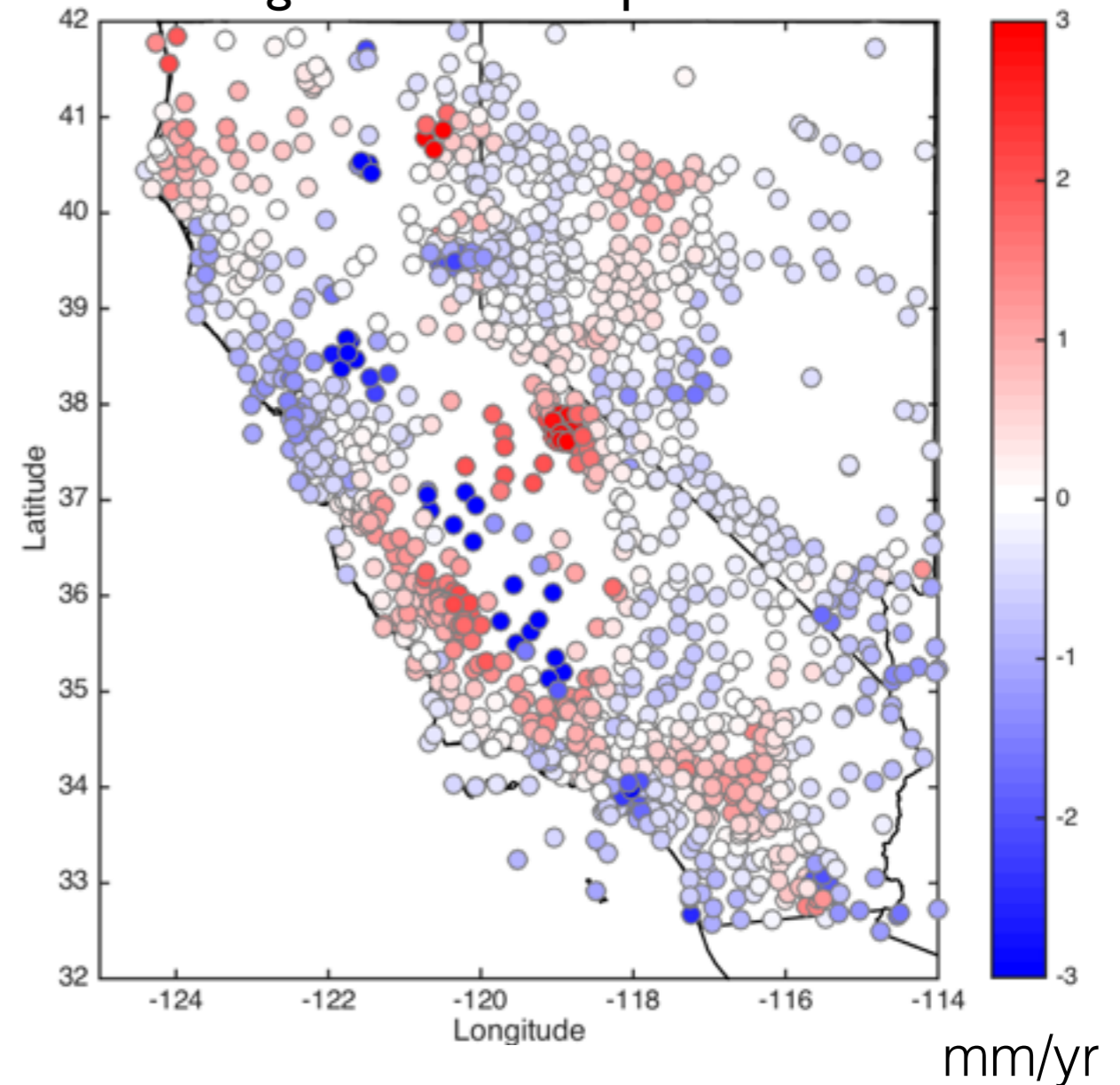


Median Spatial Filtering of GPS Velocities

MIDAS Vertical Rates



MIDAS Rates Despeckled
Weighted-Median Spatial Filtered

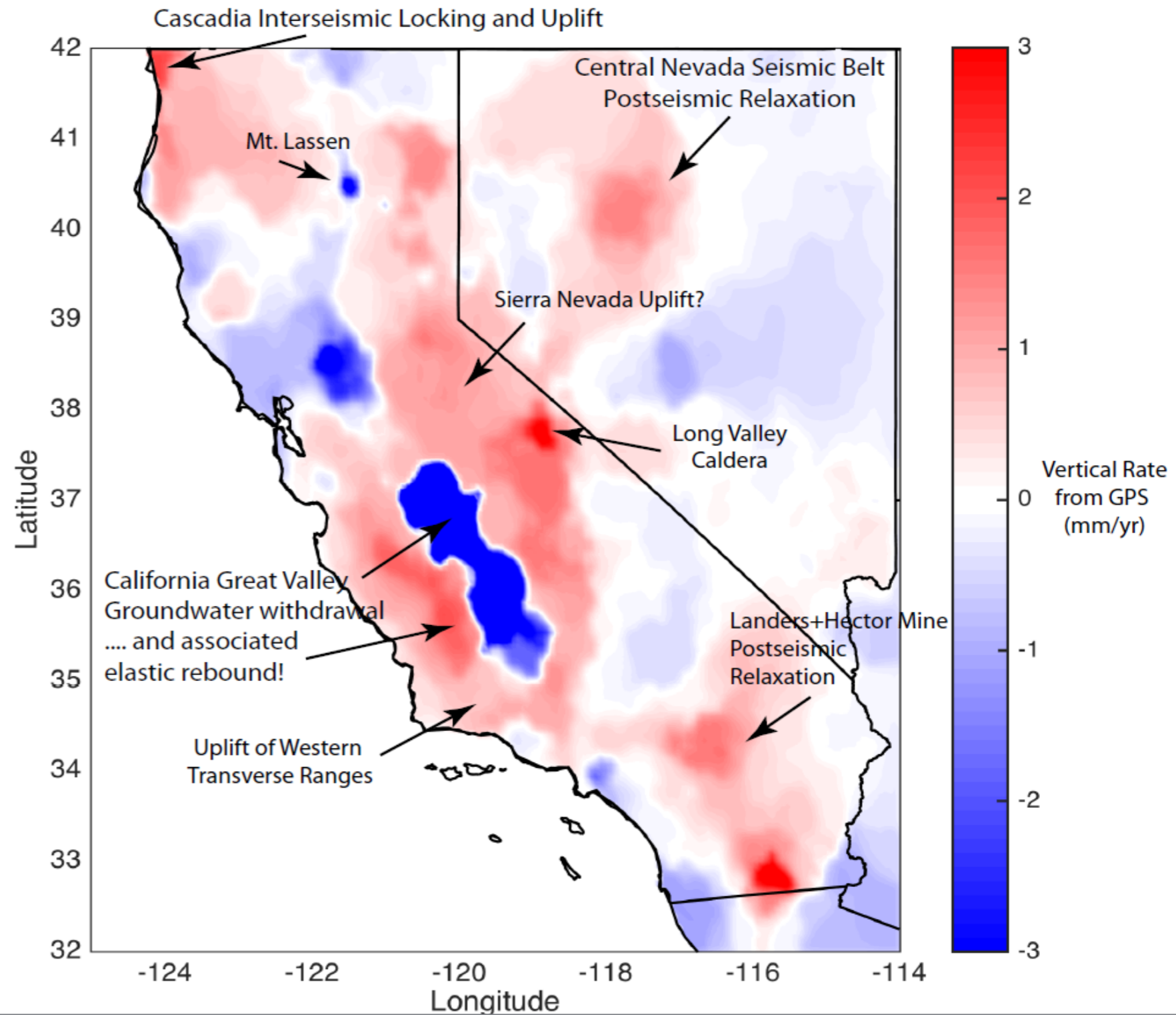


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Plug and Play Data Products: An Introduction

“GPS imaging”



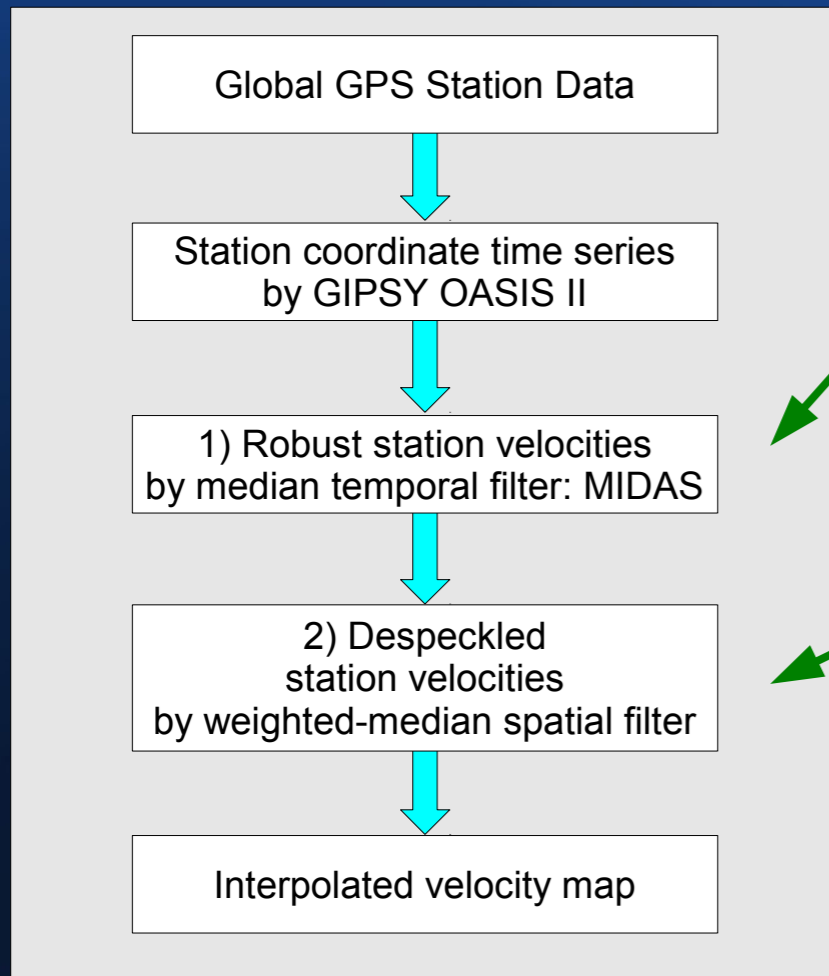
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“GPS Imaging”



How does GPS Imaging work?



1) Median filtering in the temporal domain

- MIDAS robust trend estimator
 - Based on Theil-Sen (1950, 1968)
- Find the median trend between pairs of points separated by 365 days
- Robust to outliers, seasonality, step functions

2) Median filtering in the spatial domain

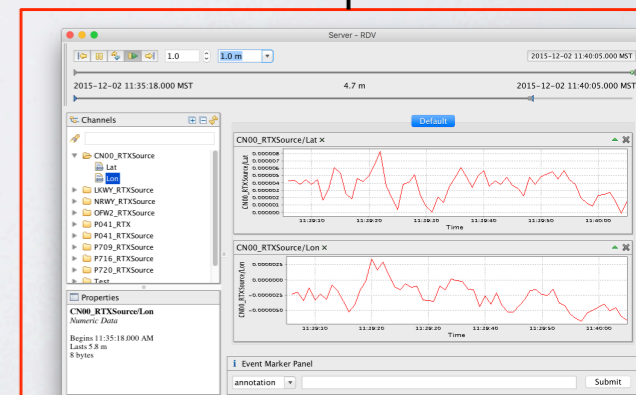
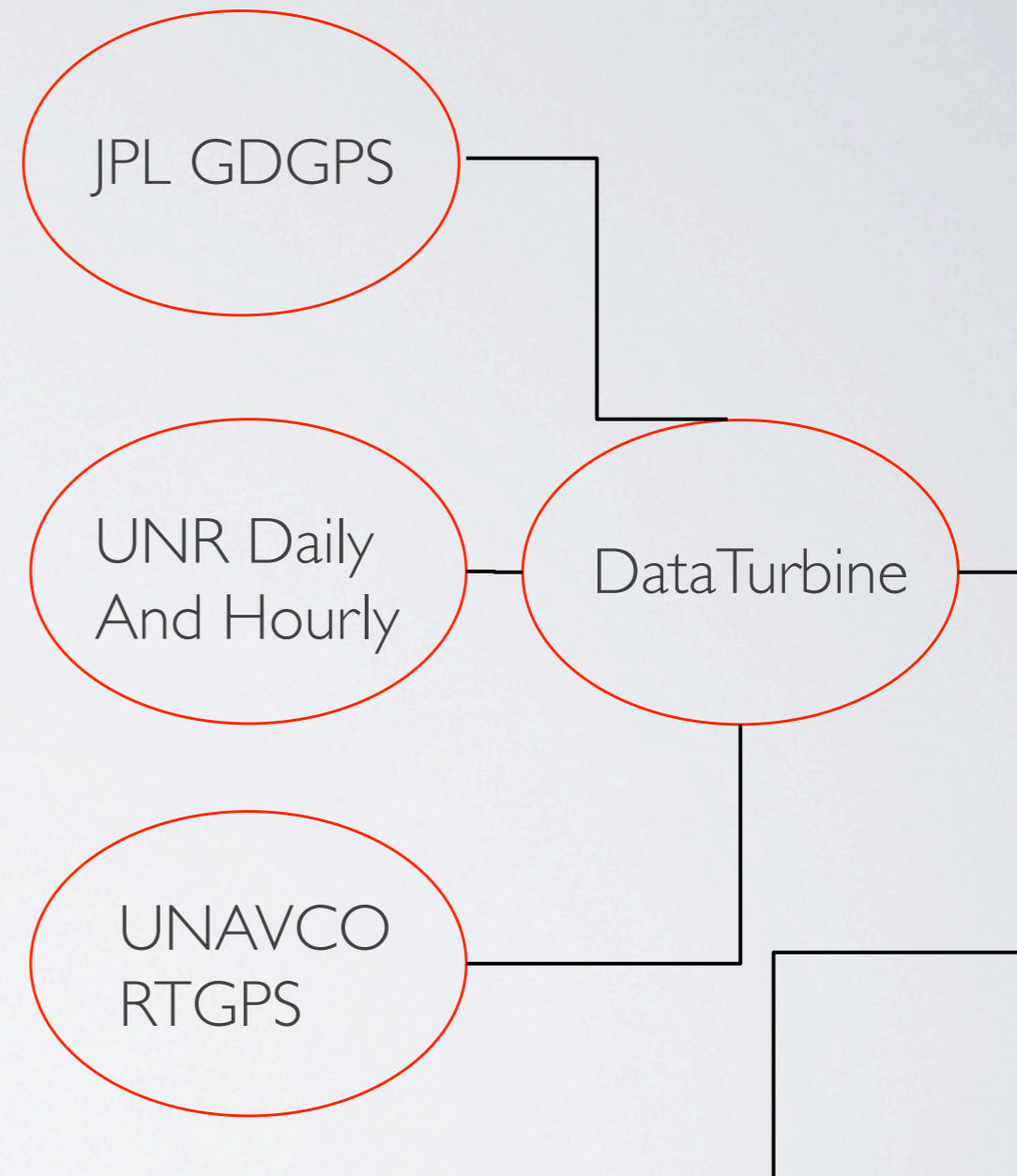
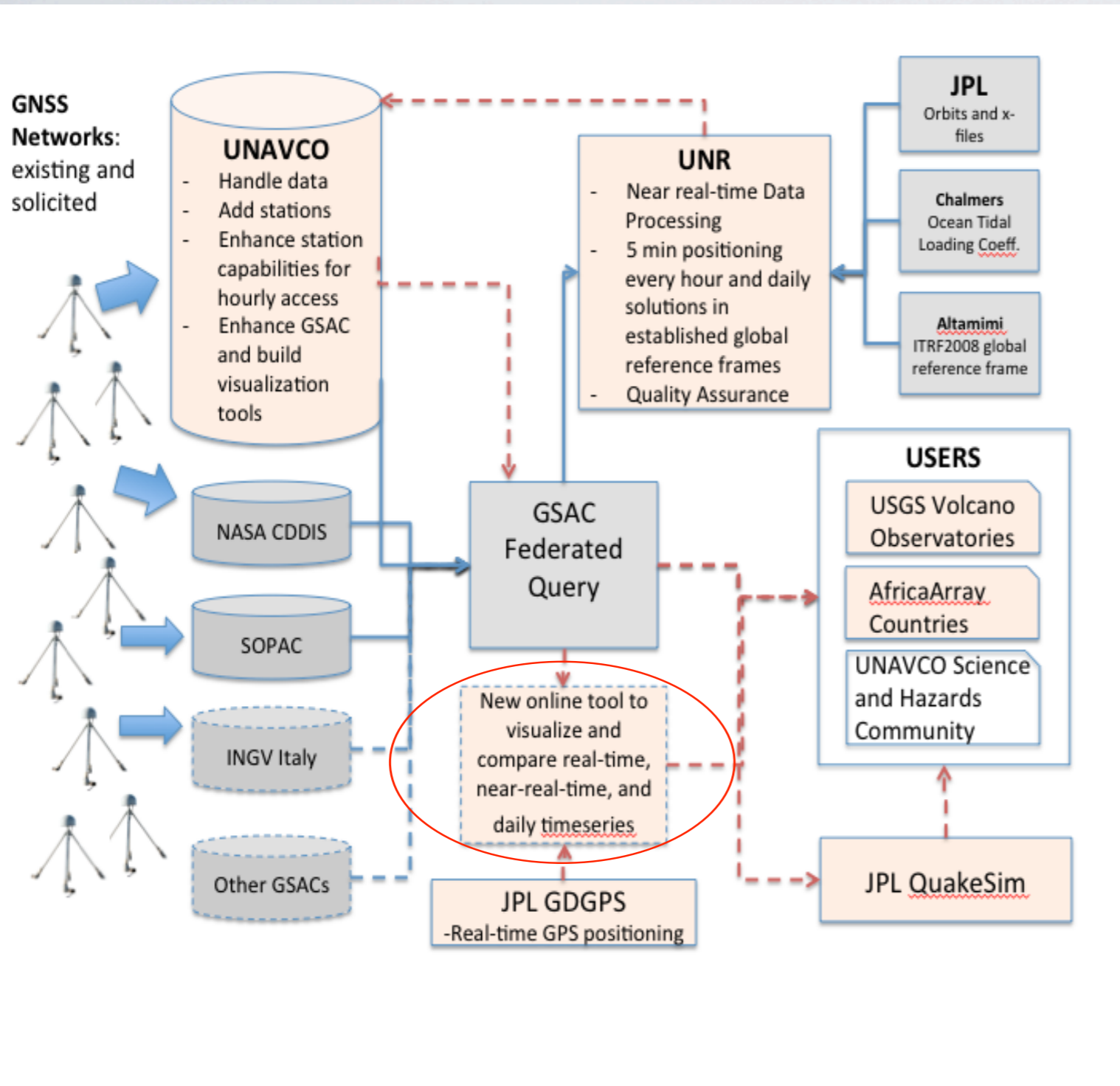
- Voting scheme on the Delauney triangulation
- Despeckles images; robust to spatial outliers
- Preserves linear boundaries between domains
- Honors the inherent resolution of the network

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Plug and Play Conceptual Workflow

Multi-sample, latency Buffer and Display



OPEN SOURCE DATA TURBINE INITIATIVE

Empowering the Scientific Community with Streaming Data Middleware

Home News Publications Documentation Sensor Pod Download Contact Us

User login

Username *

Password *

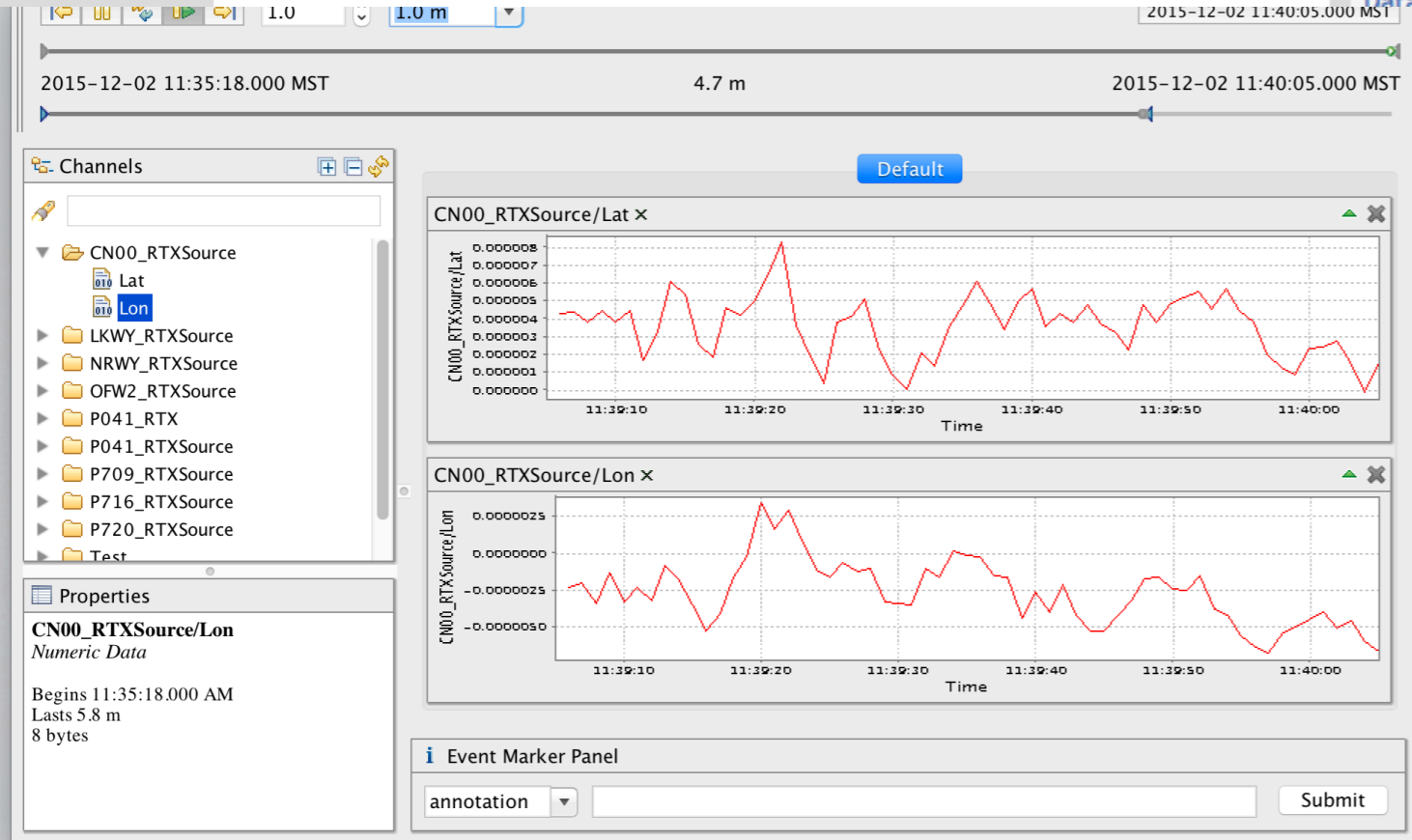
DataTurbine

In a Nutshell

DataTurbine is a *robust real-time streaming data engine* that lets you quickly stream live data from experiments, labs, web cams and even Java enabled cell phones. It acts as a "black box" to which applications and devices send and receive data. Think of it as express delivery for your data, be it numbers, video, sound or text.

Latest News

OSDT Usability Survey	Sep 29 2015
New OSDT Flyer Available	Sep 15 2015
DataTurbine V3.4R3 Now Available	Jun 11



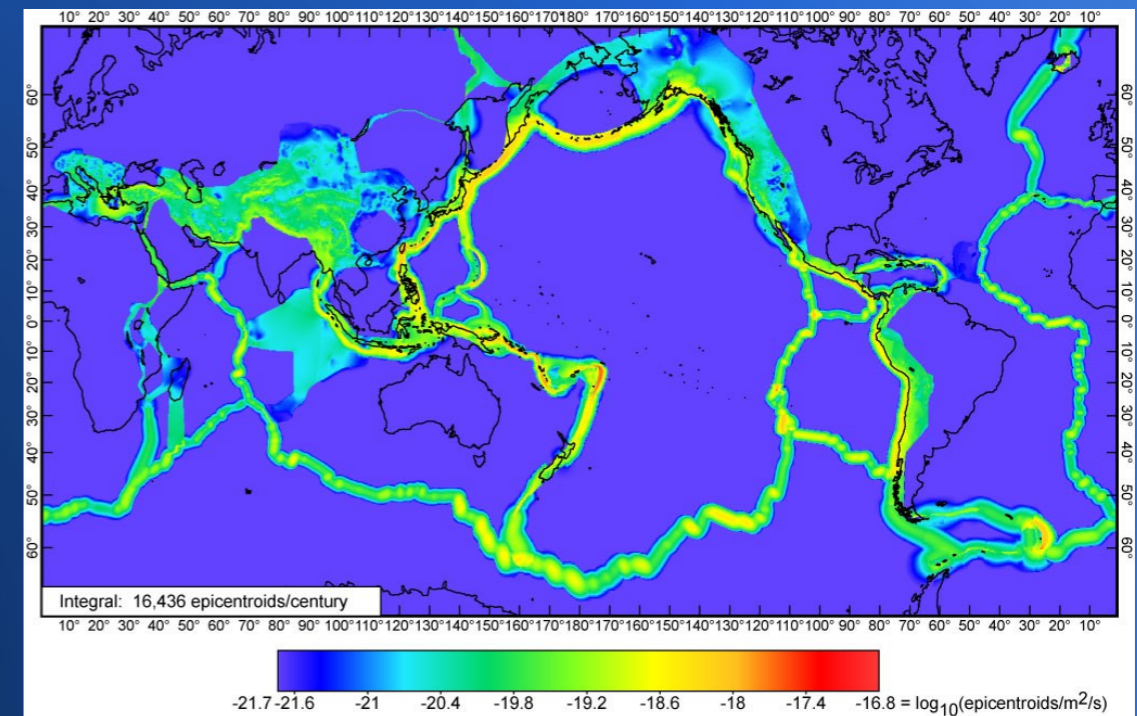
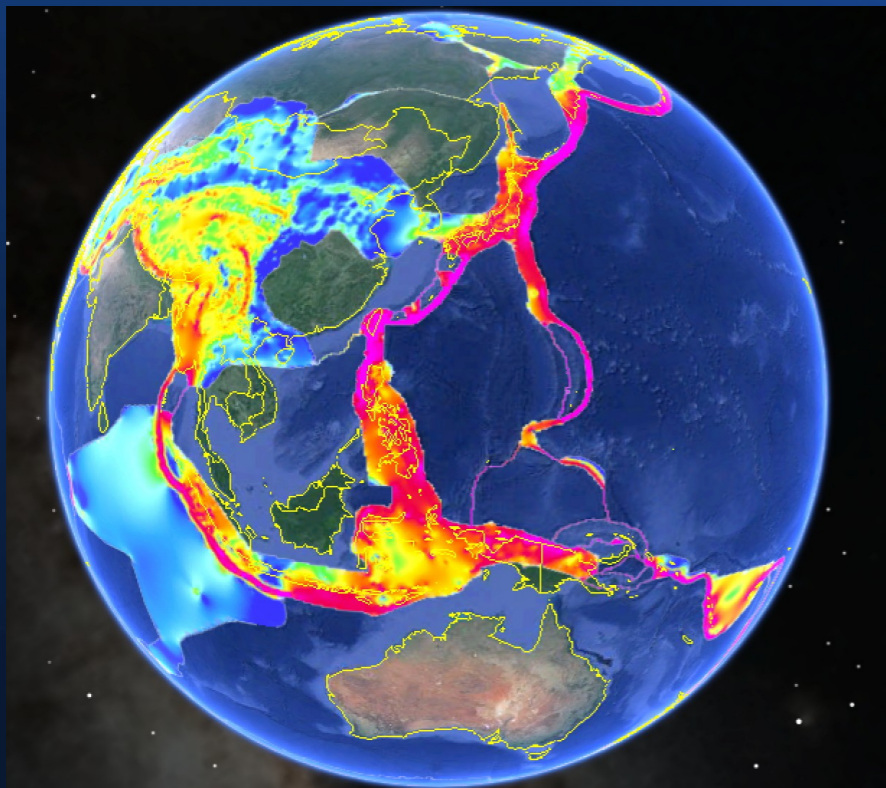
Daily, hourly and streaming 1 sec GPS data and strainmeter data will be ingested into a DataTurbine providing a time-buffered storage and common access for plotting and viewing.

Strain Rate Maps



GPS data are used to image crustal deformation.

- Global Strain Rate Map [Kreemer et al., 2014]
- Earthquake Forecast [Bird & Kreemer, 2015]



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Products Coming Soon (some Imminent, some Aspirational)

Suggestions Welcome!

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End of Section on Description of Data Products

Questions?

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How To Participate and Sign Up (The *Plug*)

The Basic Arrangement

- 1) **You** put your data online so UNAVCO can access it
- 2) **We** provide data products, free of charge
- 3) **Access** to data products remain open and unrestricted to all

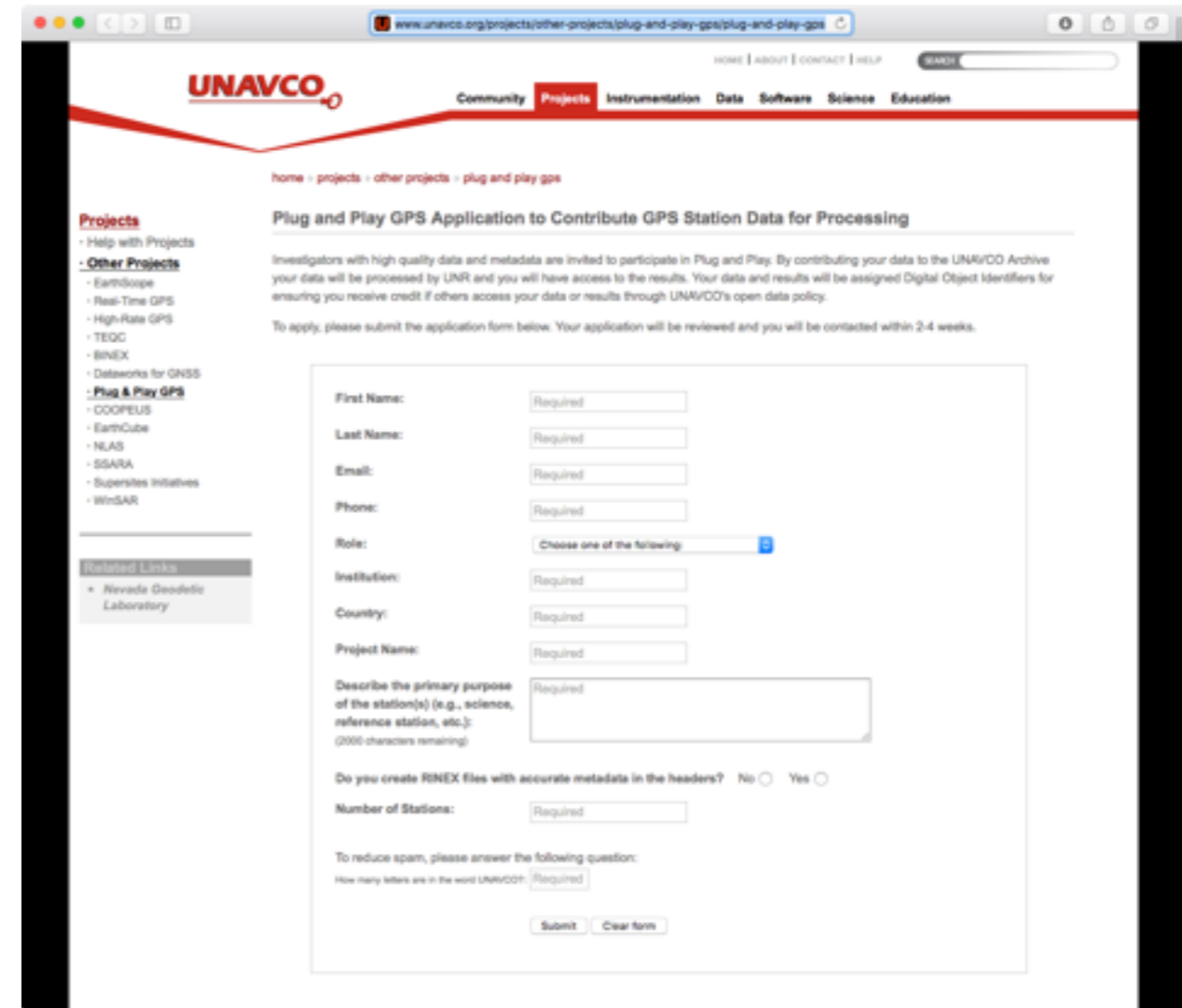


How To Participate and Sign Up (The *Plug*)

Easy! Go To:

<http://www.unavco.org/projects/other-projects/plug-and-play-gps/plug-and-play-gps-application.html>

- Takes you to UNAVCO's registration form
- Very Simple:
 - Name
 - Email
 - Phone number
 - Role
 - Country
 - Project Name
 - Describe primary purpose of station (e.g. Science, reference station)
 - Do you create RINEX with accurate metadata in the headers? (Y/N)
 - Number of stations
- Sends and email to the PnP Team Members



The screenshot shows the UNAVCO website's registration page for the Plug and Play GPS Application. The page title is "Plug and Play GPS Application to Contribute GPS Station Data for Processing". The form includes the following fields:

- First Name: Required
- Last Name: Required
- Email: Required
- Phone: Required
- Role: Choose one of the following (dropdown menu)
- Institution: Required
- Country: Required
- Project Name: Required
- Describe the primary purpose of the station(s) (e.g., science, reference station, etc.): (2000 characters remaining)
- Do you create RINEX files with accurate metadata in the headers? No Yes
- Number of Stations: Required
- To reduce spam, please answer the following question: How many letters are in the word UNAVCO? (Required)

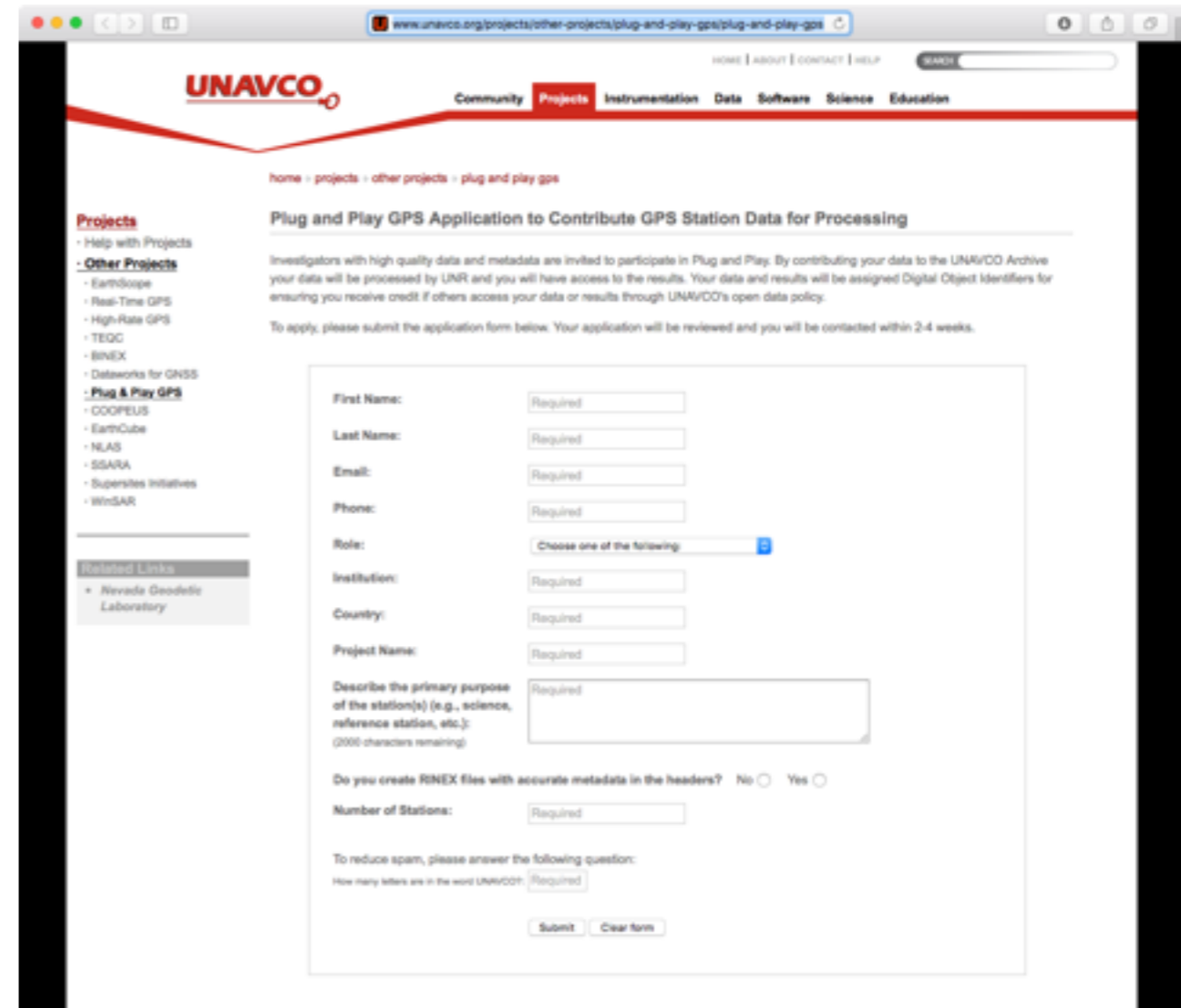
Buttons for "Submit" and "Clear form" are located at the bottom of the form.



How To Participate and Sign Up (The *Plug*)

Then What?

- Someone will contact you, email probably.
- This is new, rollout this week.
- Beta Mode
- Who will be first?
- You will get instructions on how to get RINEX to UNAVCO
 - directory structures, etc.
- Review of data, possibly you will get some feedback on suitability/completeness of data
- Metadata are crucial. Compete headers needed!
- Once UNAVCO approves UNR will be made aware of it and pick it up for processing + products.



The screenshot shows the UNAVCO website interface for the 'Plug and Play GPS Application'. The page title is 'Plug and Play GPS Application to Contribute GPS Station Data for Processing'. The form includes the following fields:

- First Name: Required
- Last Name: Required
- Email: Required
- Phone: Required
- Role: Choose one of the following
- Institution: Required
- Country: Required
- Project Name: Required
- Describe the primary purpose of the station(s) (e.g., science, reference station, etc.): (2000 characters remaining)
- Do you create RINEX files with accurate metadata in the headers? No Yes
- Number of Stations: Required
- To reduce spam, please answer the following question: How many letters are in the word UNAVCO?: Required

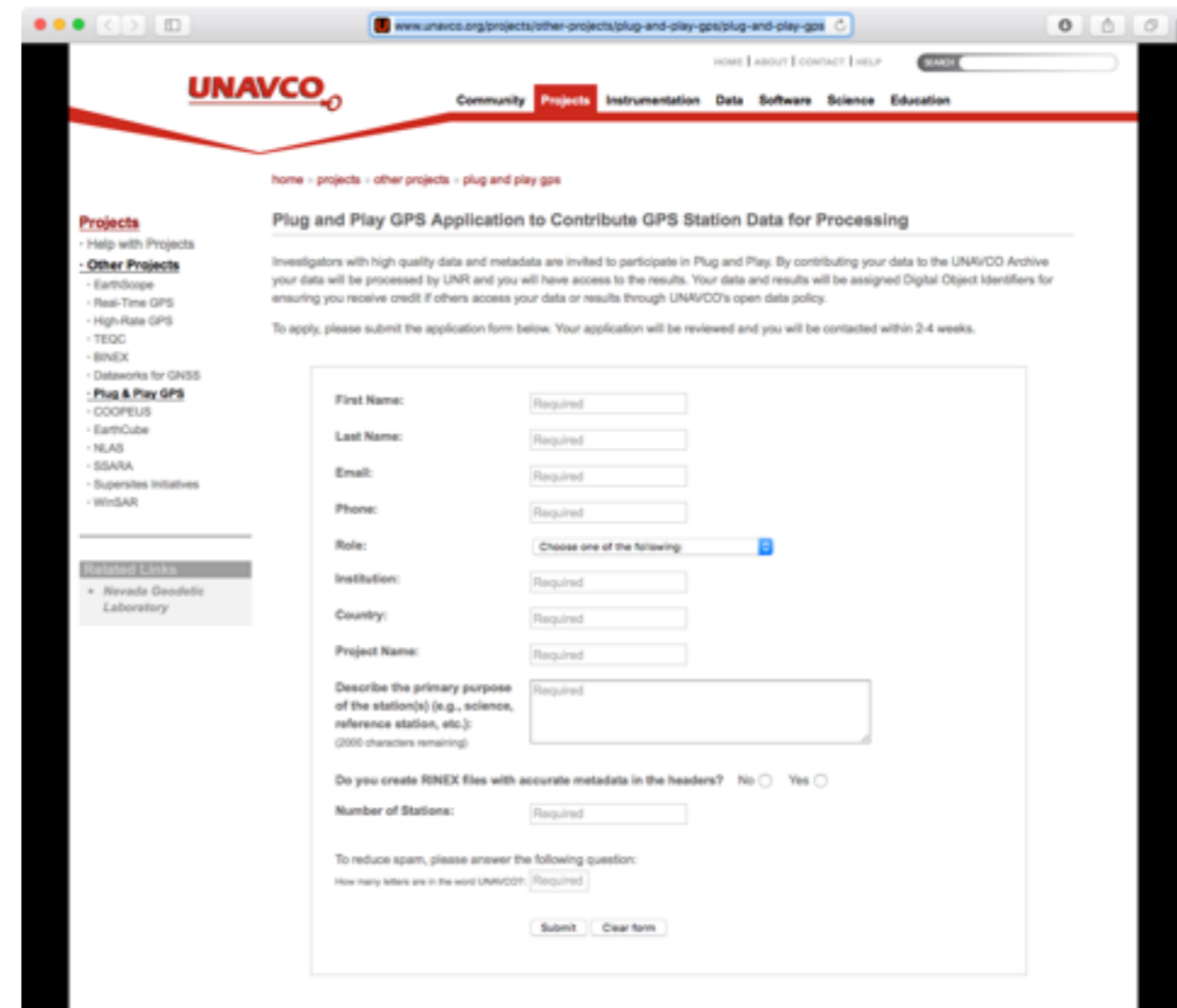
Buttons for 'Submit' and 'Clear form' are located at the bottom of the form.



How To Participate and Sign Up (The *Plug*)

Then What?

- We know this works because we already are doing it
- How is this different than what we do now?
- Check and see if your data are already in our system.



The screenshot shows the UNAVCO website's 'Plug and Play GPS Application' page. The page title is 'Plug and Play GPS Application to Contribute GPS Station Data for Processing'. The text explains that investigators with high quality data and metadata are invited to participate. It states that data will be processed by UNR and assigned Digital Object Identifiers. The application form includes the following fields:

- First Name: Required
- Last Name: Required
- Email: Required
- Phone: Required
- Role: Choose one of the following
- Institution: Required
- Country: Required
- Project Name: Required
- Describe the primary purpose of the station(s) (e.g., science, reference station, etc.): Required (2000 characters remaining)
- Do you create RINEX files with accurate metadata in the headers? No Yes
- Number of Stations: Required
- To reduce spam, please answer the following question: How many letters are in the word UNAVCO?: Required

Buttons for 'Submit' and 'Clear form' are located at the bottom of the form.

How To Participate and Sign Up (The *Plug*)

See One Page Handout on Plug and Play:

Has clickable link so you don't have to remember it all.



Plug and Play GPS for You!

Access to the benefits of high precision, low-latency position time series from global GPS networks is currently limited by the need to have advanced expertise and systems for data acquisition and processing. We are taking steps to remove these barriers by developing a system capable of processing all GPS data available in open archives. Currently we process data from over 14,000 continuously operating stations from around the globe. For openly contributed data, this rigorous and automated system provides processed data products (e.g. position time series, plots, velocities, etc.) free of charge. Results are provided with low latency suitable for rapid modeling and analysis of natural hazards from earthquakes, tsunamis, volcanoes, hydrologic changes, and other applications.

Plug and Play GPS Processing

We will provide you with daily and 5-minute position time series and quality control products, with latency between 2 hours and 1 day depending upon data availability. The University of Nevada, Reno (UNR), processes contributed data using products provided by the Jet Propulsion Laboratory (JPL), including ultra-rapid GPS orbits and clock parameters, and JPL's GIPSY/OASIS II software. The processed time series are presented in global (IGS08) and North America (NA12) reference frames.

Participating in Plug and Play

Plug and Play GPS participants submit high quality data and metadata to the UNAVCO Archive where the Data Center services provide data ingestion, access, formatting and cataloging of accurate metadata including proper source attribution. UNR then picks up hourly

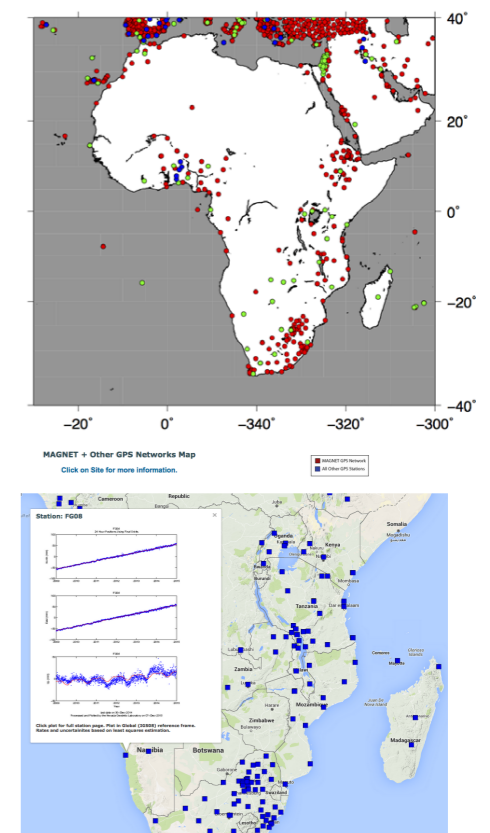
Getting Started: How to Contribute Your GPS Data

To get started, fill out a short web form describing your data at <http://www.unavco.org/projects/other-projects/plug-and-play-gps/plug-and-play-application.html>

Accessing Processed Results

Time series plots and files, and post-processed station quality control factors, are cataloged in a Geodetic Seamless Archive Centers (GSAC) database that is searchable and accessible via web browsers or via newly developed simple RESTful web services. Products themselves are located at the UNR Nevada Geodetic Laboratory (<http://geodesy.unr.edu/>). To promote open exchange, processed data products are made openly available to all.

UNAVCO, a non-profit, membership-governed consortium, supports and promotes Earth science by advancing high-precision techniques for the measurement and understanding of deformation. UNAVCO also supports education to meet the needs of the community and the public.



How To Participate and Sign Up (The *Play*)

See Previous Data Products Section

- Once in the system all data are brought through to products
- Caveat: MIDAS rates require >1 year of data before they are produced
 - (Uplift maps usually need >4 or 5 years)
 - But time series should be available very quickly.
 - Conceivably within hours of if hourly files are provided.

How To Participate and Sign Up (The *Play*)

What you can do right now

Browse the data products

Use the data products

Incorporate data products into your workflow

Incorporate data products into educational resources

See examples case study on Napa M_w 6.0 earthquake

Provide feedback to us!

whammond@unr.edu



How To Participate and Sign Up (The *Play*)

Questions?



Case Study: The August 24, 2014 Napa Mw6.0 Earthquake

<http://earthquake.usgs.gov/earthquakes/eventpage/nc72282711>



USGS
science for a changing world

Earthquake Hazards Program

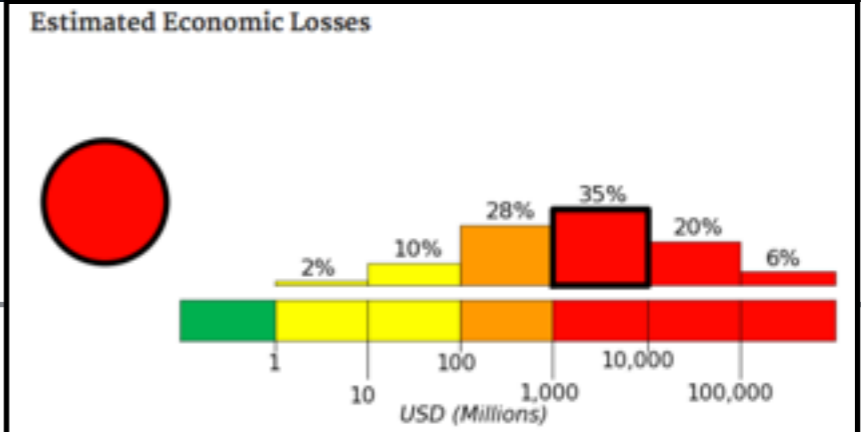
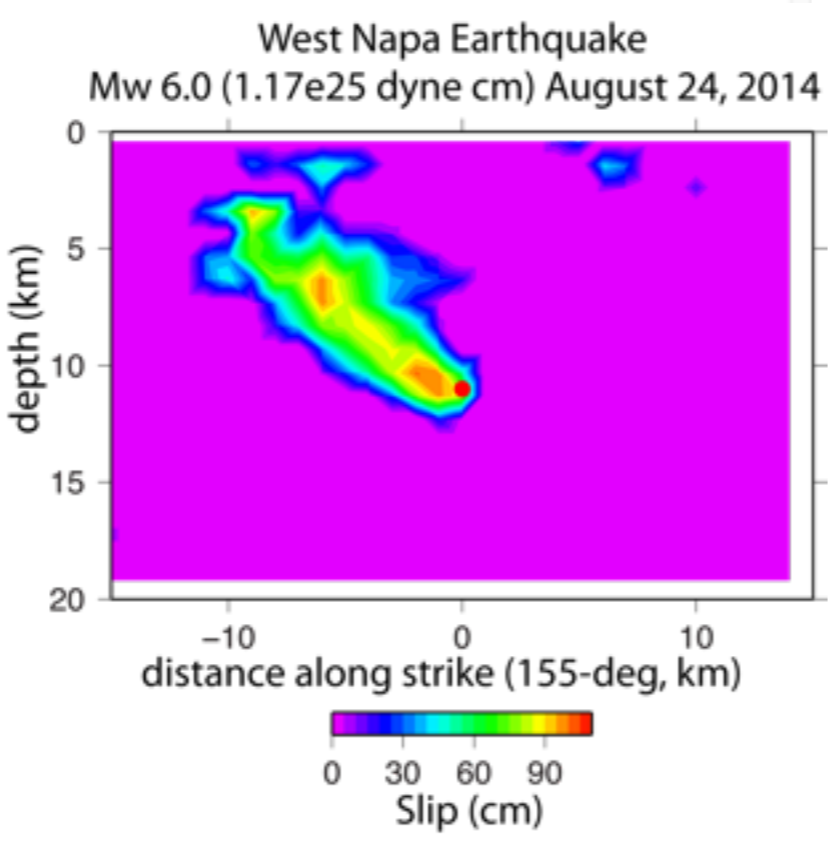
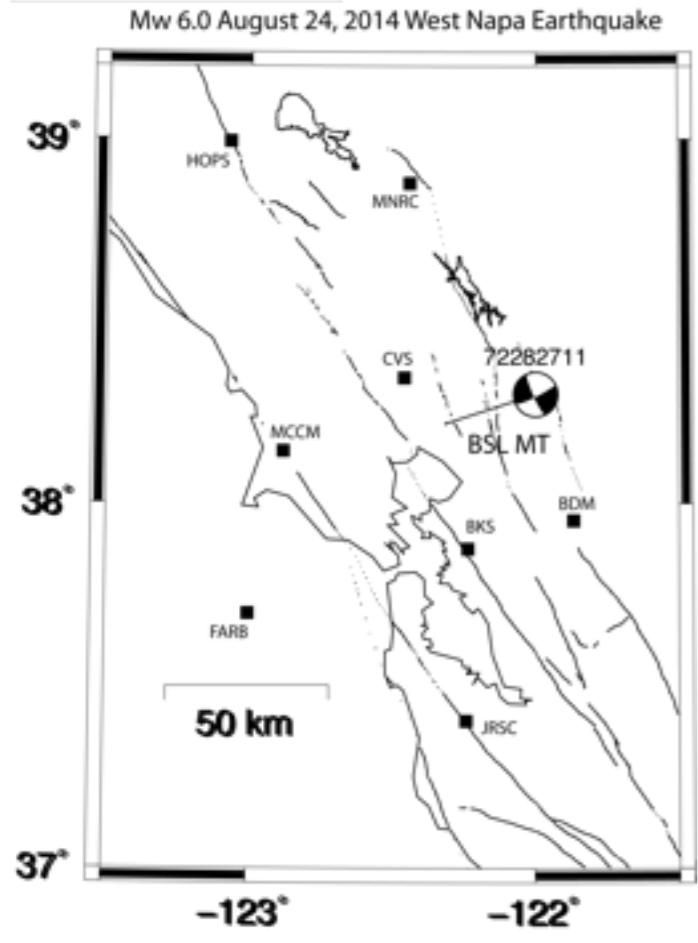
General

M6.0 - 6km NW of American Canyon, California

VIII DYFI IX ShakeMap RED PAGER

Scientific - Finite Fault

Data Source US*



Red alert level for economic losses. Extensive damage is probable and the disaster is likely widespread. Estimated economic losses are less than 1% of GDP of the United States. Past events with this alert level have required a national or international level response.

Case Study: The August 24, 2014 Napa Mw6.0 Earthquake

Imagine this happens

And you want GPS solutions.

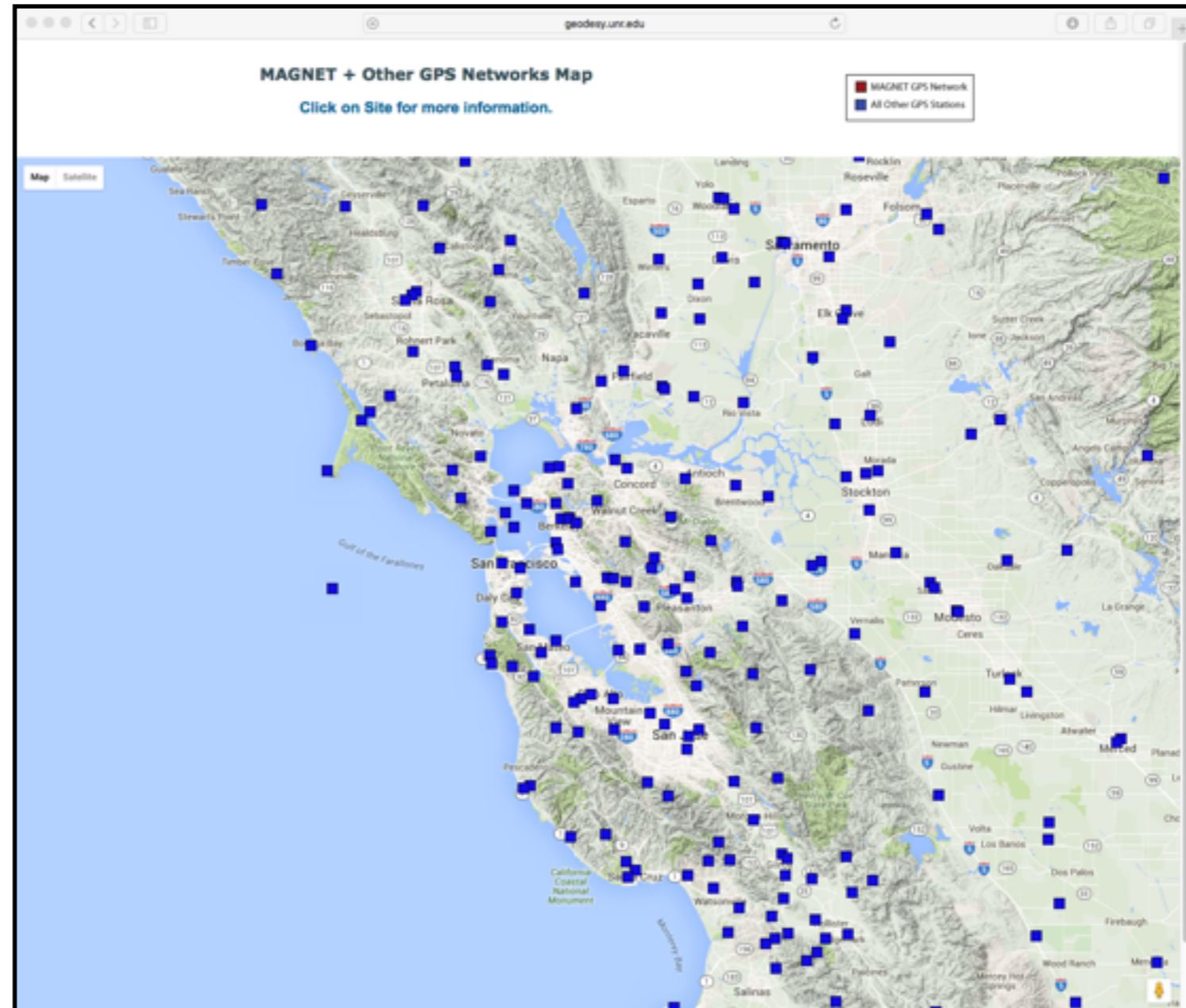
You go to <http://geodesy.unr.edu/>
You see there are many stations ...

You might want an example time series.
You might want to grab a couple plots.

Hover your mouse to get station name.

Or if you want everything and you are OK writing scripts you might try the:

- Data Holdings files...
- GSAC search tools...



Case Study: The August 24, 2014 Napa Mw6.0 Earthquake

Imagine this happens

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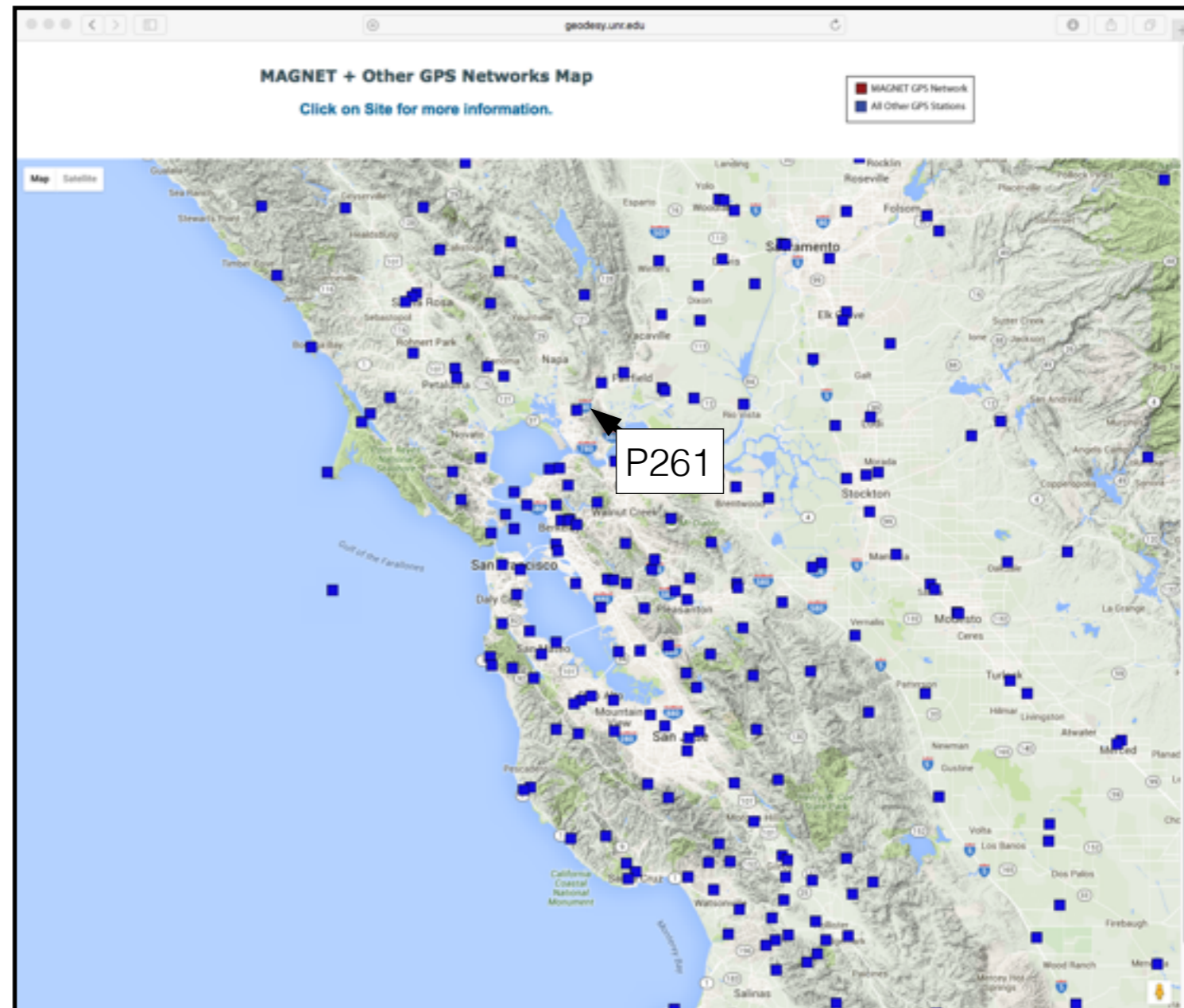
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Case Study: The August 24, 2014 Napa Mw6.0 Earthquake

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And you want GPS solutions.

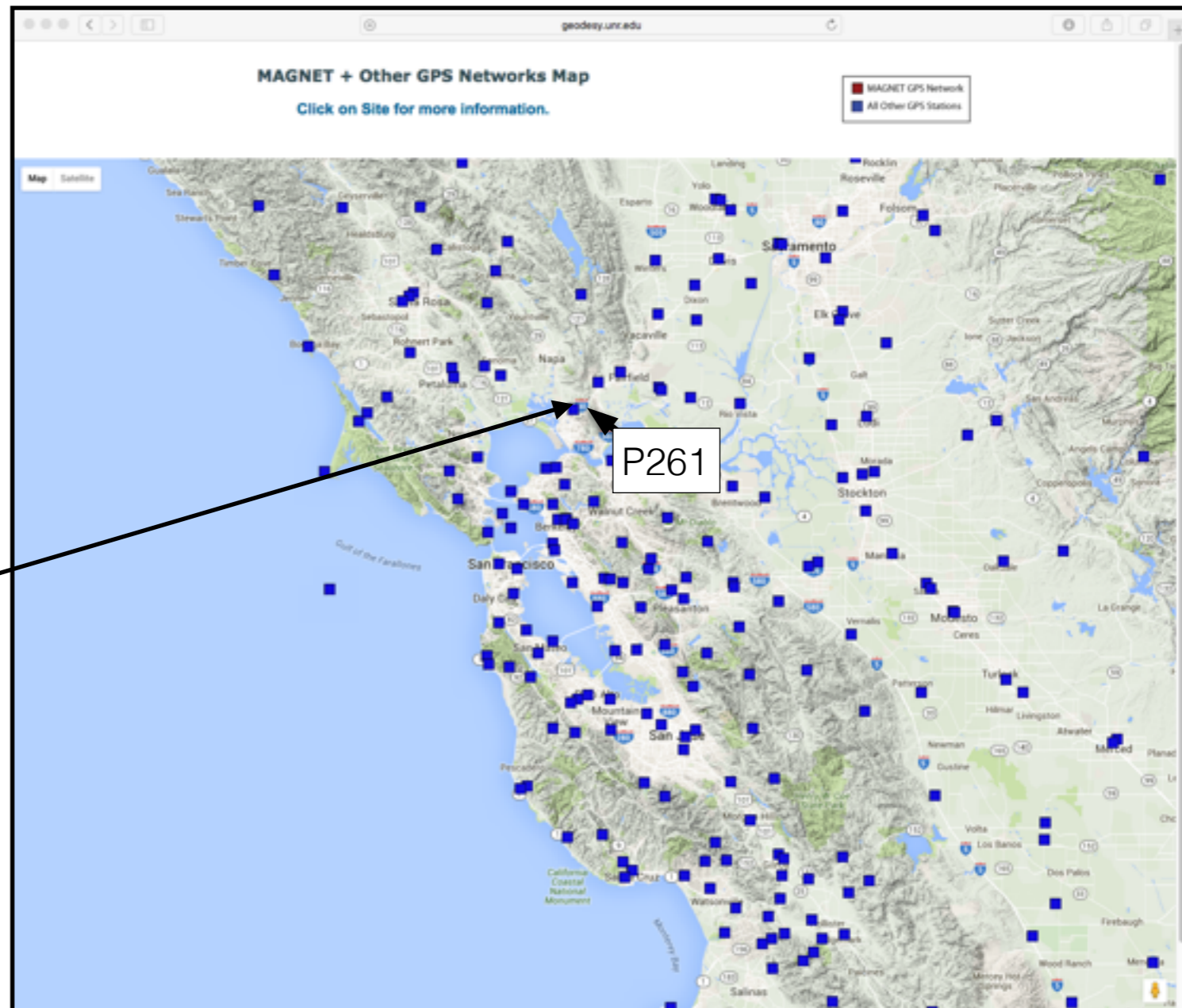
You go to <http://geodesy.unr.edu/>
You see there are many stations ...

You might want an example time series.
You might want to grab a couple plots.

Hover your mouse to get **click!** me.

Or if you want everything and you are OK writing scripts you might try the:

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- GSAC search tools...



Case Study: The August 24, 2014 Napa Mw6.0 Earthquake

Imagine this happens

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Hover you mouse to get station name.

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The screenshot shows the Nevada Geodetic Laboratory website. The header includes the logo and navigation links: Home, Browse Global Station List, Browse Rapid Station List, Browse Ultra Rapid Station List, Map Browse, and Acknowledgements. The main content area is for Station ID: P261. It provides station operator information (from RINEX headers), data processed by (Geoffrey Blewitt, Nevada Geodetic Lab.), and coordinates (Latitude: 38.153, Longitude: -122.218, Height: 118.175 meters). A map shows the station location near Vallejo, CA. Below the map is a table of data holdings:

Time Series Data (ascii text)		
24 Hour Final Solutions		
IGS08	env	xyz
NA12	env	xyz
24 Hour Rapid Solutions		
FID (~IGS08)	env	
NA12	env	
env readme	xyz readme	
QA files	ftp link	
Rapid 5 Minute Solutions Available Next Day (8-32 hr. latency)		
env	ftp link	

Below the table is a section for Station Plots, with an explanation of plots. A plot titled "P261 24 Hour Positions Using Final Orbits (Blue) Using Rapid Orbits (Magenta)" shows North position (mm) on the y-axis (ranging from -20 to 20) versus time on the x-axis (ranging from 2004 to 2016). The plot shows a clear upward trend in position over time, with a sharp drop in 2014 corresponding to the earthquake. The plot includes data points and fitted curves for both final and rapid orbits.

Case Study: The August 24, 2014 Napa Mw6.0 Earthquake

Imagine this happens

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You go to <http://geodesy.unr.edu/>
You see there are many stations ...

If you want an example time series
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Hover you mouse to get station name.

Or if you want everything and you are
OK writing scripts you might try the:

- Data Holdings files...
- GSAC search tools

The screenshot shows the Nevada Geodetic Laboratory website. The header features a banner image of a GPS antenna with the text "Nevada Geodetic Laboratory". Below the banner is a navigation menu with links: Home, People, Contact, About us, Links, Vacancies, Site Map, News Archive, MAGNET, and Acknowledgements. The main content area is divided into three columns. The left column contains "Current Research" (Great Basin Strain, Basin and Range Dynamics, Aquifer Deformation, Geothermal Energy, Global Tectonics, Reference Frames, Global Strain Rate Map, Yucca Mountain GPS, Publications), "MAGNET GPS Network" (Network Information), "People" (Geoff Blewitt, Hans-Peter Plag, Bill Hammond, Corné Kreemer, Elliot Klein, Bret Pecoraro, Jayne Bormann, Jay Goldfarb, Yang Zhang), and "Opportunities" (Students, Postdocs). The middle column is titled "Latest News" and contains two news items: one from December 14, 2015, about a new database product, and one from October 2015, about new publications. The right column is titled "Data Products" and lists various data holdings, including "Map Browse GPS Stations", "FTP Access to GPS Data Products", "GPS Data Processing Strategy", "MAGNET GPS network", "Guide to QA Files", "Publications", "MIDAS Velocity Fields", "Browse Lists of Stations", and "Downloadable Lists of GPS Data Holdings". A red circle highlights the "Downloadable Lists of GPS Data Holdings" section, which includes options like "Download List of GPS Station Latitude, Longitude, Height" and "Stations with 5 minute sample rate solutions, ultra rapid orbits, 1.5 hour latency".



Case Study: The August 24, 2014 Napa Mw6.0 Earthquake

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You go to <http://geodesy.unr.edu/>
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Sta	Lat(deg)	Long(deg)	Hgt(m)	X(m)	Y(m)	Z(m)	Dtbeg	Dtend	Dtmod	NumSol	StaOrigName
INSU	31.7508	266.9024	28.071	-293349.5323	-5420742.3561	3336980.8353	2013-03-31	2015-12-21	2015-12-21	909	
IULM	32.5290	267.9241	16.000	-194982.0141	-5379221.9515	3410046.8330	2013-03-31	2015-12-21	2015-12-21	913	
AB06	54.8853	196.5765	500.412	-3524499.4933	-1049128.1698	5194460.0380	2015-03-10	2015-12-21	2015-12-21	253	
ABMP	16.2623	298.4725	-25.520	2919785.7182	-5383745.0998	1774604.7044	2013-09-01	2015-12-20	2015-12-21	340	
ABPO	-19.0183	47.2292	1552.968	4097216.6713	4429119.0040	-2065771.3588	2013-03-30	2015-12-21	2015-12-21	863	
ABQS	34.9574	253.5055	1719.740	-1486206.9395	-5019130.4708	3634977.9941	2013-03-31	2015-12-21	2015-12-21	868	
ABQ6	34.9571	253.5055	1720.651	-1486213.0785	-5019145.7921	3634956.0771	2013-03-31	2015-12-21	2015-12-21	841	
AC06	59.7636	209.1094	631.407	-2813443.6625	-1566561.1082	5487809.0431	2013-03-06	2015-12-21	2015-12-21	935	
AC10	54.5226	195.1133	170.458	-3581775.4879	-967327.3274	5170858.1425	2013-03-30	2015-12-21	2015-12-21	882	
AC27	59.2525	205.8371	417.477	-2942366.1195	-1424747.8033	5458729.1632	2013-03-06	2015-12-21	2015-12-21	931	
AC44	61.2422	210.4329	832.131	-2652975.1418	-1558538.1576	5569105.0684	2013-03-06	2015-12-21	2015-12-21	943	
AC59	59.5672	206.4148	308.546	-2900773.1286	-1440890.3163	5476476.8003	2013-03-30	2015-12-21	2015-12-21	905	
ACOR	43.3644	351.6011	66.916	4594489.7469	-678367.8806	4357066.0719	2013-03-30	2015-12-21	2015-12-21	944	
ACU6	41.7433	289.1134	5.021	1560586.4347	-4503296.2530	4224372.1533	2013-03-31	2015-12-21	2015-12-21	866	
ADIS	9.0351	38.7663	2439.166	4913652.8146	3945922.6424	995383.2832	2013-03-06	2015-12-21	2015-12-21	780	
ADKS	29.7910	264.4136	2.831	-539282.7289	-5513496.8493	3150287.2103	2013-03-31	2015-12-21	2015-12-21	542	
ADRI	41.9190	275.9757	205.960	494838.1799	-4727340.1260	4239050.3234	2013-03-31	2015-12-21	2015-12-21	900	
AGDS	43.3127	3.4743	68.239	4639701.7515	281689.3832	4352886.9427	2013-03-30	2015-12-21	2015-12-21	900	
AGEN	44.1725	0.6115	113.739	4581960.1860	48907.6433	4421939.9182	2013-03-30	2015-12-21	2015-12-21	906	
ANTI	-38.4114	178.0460	563.258	-5001713.8688	170643.0319	-3941681.7507	2013-03-30	2015-12-21	2015-12-21	924	
AICI	43.3336	358.9856	121.401	4645961.3276	-82264.0872	4354613.6291	2013-03-30	2015-12-21	2015-12-21	904	
AILE	47.8770	3.3559	186.791	4278646.1148	250892.8509	4707853.6035	2013-03-30	2015-12-21	2015-12-21	923	
AIRS	16.7408	297.7861	84.350	2848125.5623	-5405118.8842	1825410.0082	2013-03-30	2015-12-21	2015-12-21	538	
AKTO	-40.5398	176.4612	432.984	-4845036.3645	299626.8092	-4124001.4599	2013-03-30	2015-12-21	2015-12-21	571	
ALAC	38.3389	359.5188	60.332	5009051.1878	-42072.1830	3935057.7358	2013-03-30	2015-12-21	2015-12-21	947	
ALBA	38.9779	358.1436	751.759	4962848.0483	-160854.1142	3990884.4508	2013-03-30	2015-12-21	2015-12-21	947	
ALBH	48.3898	236.5125	31.768	-2341332.9341	-3539049.5241	4745791.3564	2013-03-06	2015-12-21	2015-12-21	943	
ALBY	-34.9502	117.8102	36.637	-2441714.4885	4629128.4957	-3633363.3005	2013-03-30	2015-12-21	2015-12-21	842	
ALGO	45.9558	281.9286	200.897	918129.4502	-4346071.2523	4561977.8346	2013-03-06	2015-12-21	2015-12-21	937	
ALIC	-23.6701	133.8855	603.278	-4052052.2412	4212836.0742	-2545105.3103	2013-03-06	2015-12-21	2015-12-21	851	
ALME	36.8525	357.5406	127.500	5105220.0839	-219278.4736	3804387.1610	2013-03-30	2015-12-21	2015-12-21	949	
AMB2	45.5406	3.7501	617.593	4465758.6670	292711.8090	4530070.4313	2013-03-30	2015-12-21	2015-12-21	919	
AMC2	38.8031	255.4754	1911.378	-1248596.1223	-4819428.2054	3976505.9986	2013-03-06	2015-12-21	2015-12-21	911	
AMNR	49.8588	2.2384	90.083	4116794.2688	160912.1488	4852750.3078	2013-03-30	2015-12-21	2015-12-21	903	
ANAU	-38.2682	178.2912	229.333	-5011995.6454	149520.9784	-3929003.1700	2013-03-30	2015-12-21	2015-12-21	921	
ANAY	45.2403	4.6817	440.915	4483964.8412	367206.3053	4506508.0413	2013-03-30	2015-12-21	2015-12-21	930	
ANC2	61.1752	210.0166	57.847	-2669568.0785	-1542304.6878	5564833.2817	2013-03-31	2015-12-21	2015-12-21	891	
ANDA	-30.4533	137.1601	101.383	-4035145.4404	3741808.3966	-3213842.9272	2013-03-30	2015-12-21	2015-12-21	866	
ANG6	29.3016	264.5151	-9.193	-532066.3713	-5541057.6820	3103095.7751	2013-03-31	2015-12-21	2015-12-21	873	
ANG8	47.4719	359.4522	106.085	4319044.8436	-41298.9857	4677465.3443	2013-03-30	2015-12-21	2015-12-21	911	
ANSR	39.8874	32.7585	976.044	4121948.5432	2652187.9132	4069023.7579	2013-03-30	2015-12-21	2015-12-21	884	
ANPS	39.0103	283.3908	20.425	1149298.5282	-4827706.9105	3993217.3498	2013-03-31	2015-12-21	2015-12-21	885	
ANP6	39.0105	283.3909	21.630	1149308.4318	-4827688.8935	3993238.0682	2013-03-31	2015-12-21	2015-12-21	859	
AQUT	42.3682	13.3502	713.126	4592507.6895	1089876.2844	4276392.9656	2013-03-30	2015-12-21	2015-12-21	953	
ARAN	45.7152	5.4247	289.198	4441254.0025	421757.2443	4543411.7302	2013-03-30	2015-12-21	2015-12-21	895	
ARBT	35.7099	268.3715	91.978	-147353.9749	-5182834.6310	3702154.3785	2013-04-02	2015-12-21	2015-12-21	876	
ARRQ	-16.4655	288.5072	2488.945	1942826.7760	-5804070.2662	-1796893.9282	2013-03-06	2015-12-21	2015-12-21	902	
ARBE	-16.4655	288.5072	2488.914	1942826.2195	-5804070.3314	-1796894.2053	2013-03-06	2015-12-21	2015-12-21	733	
ARFY	36.1158	265.8200	349.603	-376023.4749	-5144995.6604	3738785.1493	2013-04-02	2015-12-21	2015-12-21	769	
ARGI	61.9974	353.2165	110.251	2981489.7505	-354651.5492	5608475.0165	2013-03-30	2015-12-21	2015-12-21	943	
ARHP	33.6961	266.3994	84.484	-333601.0133	-5301621.2679	3518493.8668	2013-04-02	2015-12-21	2015-12-21	874	
ARRR	36.1842	266.9698	332.327	-272465.1386	-5147017.5566	3744907.4739	2013-04-02	2015-12-21	2015-12-21	837	
ARLR	34.6726	267.6174	73.224	-218301.6716	-5246693.4162	3608099.4873	2013-04-02	2015-12-21	2015-12-21	878	
ARMS	36.3692	267.6269	227.718	-212916.3827	-5137582.7511	3761395.8751	2013-03-31	2015-12-21	2015-12-21	878	
ARNA	47.9465	0.1809	36.785	4280128.1284	13517.8849	4717367.1504	2013-03-30	2015-12-21	2015-12-21	901	

Stations with 24 sample rate solutions, rapid orbits, 24 hour latency.

Stations with 5 minute sample rate solutions, ultra rapid orbits, 1.5 hour latency.

Blewitt, 2015, Terrestrial reference frame requirements for studies of geodynamics and climate change. *International Association of Geodesy Symposia*, 1-8, doi:10.1007/1345_2015_142. (PDF)

Bird, P., and C. Kreemer, 2015. Revised tectonic forecast of global shallow seismicity based on version 2.1 of the Global Strain Rate Map. *Bulletin of the Seismological Society of America*, 85(1), 1-15. doi:10.1785/BSSA-135-1-1-15. (PDF)



Case Study: The August 24, 2014 Napa Mw6.0 Earthquake

Imagine this happens

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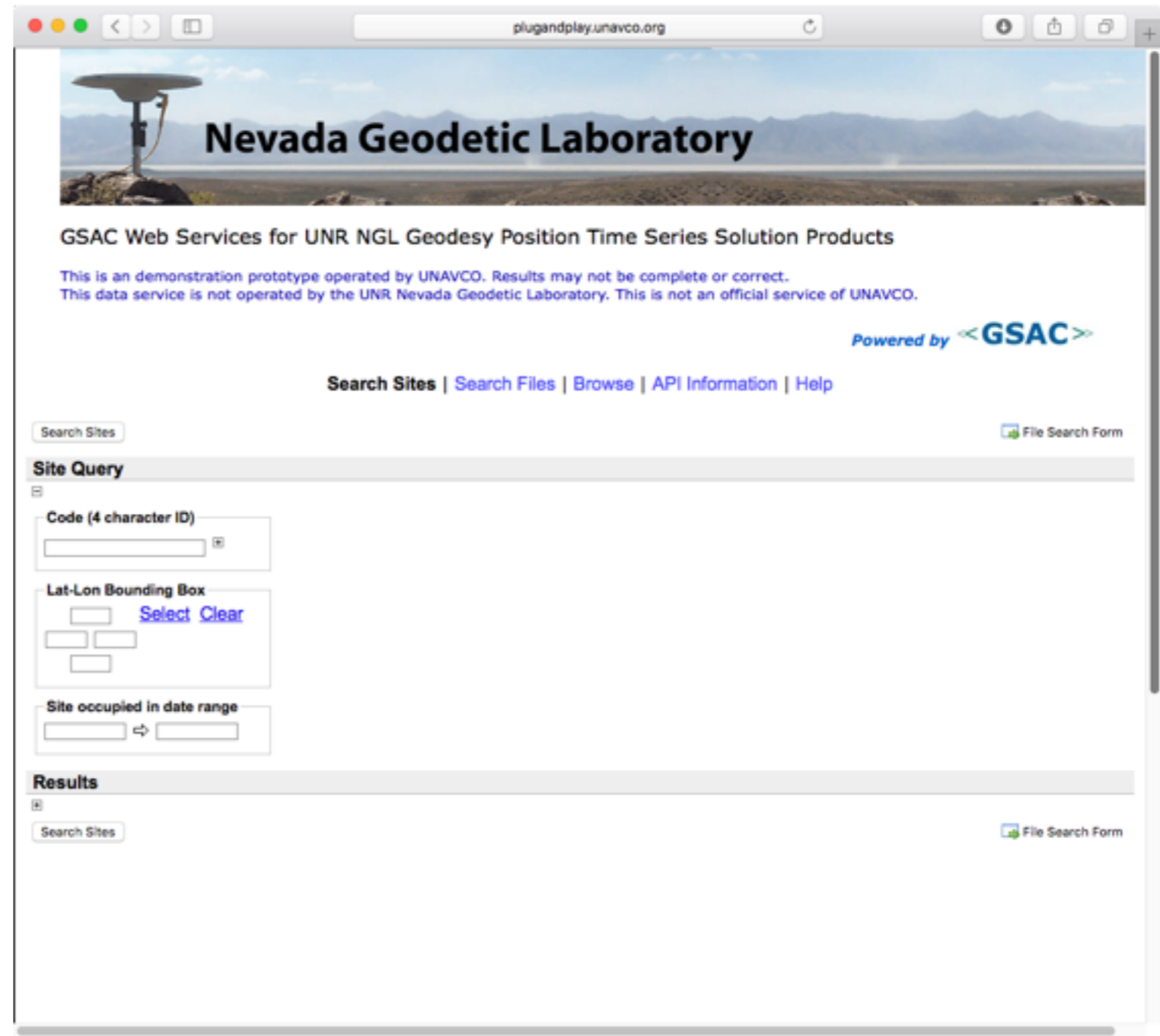
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- GSAC search tools



The screenshot shows a web browser window with the URL `plugandplay.unavco.org`. The page header features a banner image of a GPS antenna with the text "Nevada Geodetic Laboratory". Below the banner, it reads "GSAC Web Services for UNR NGL Geodesy Position Time Series Solution Products". A disclaimer states: "This is an demonstration prototype operated by UNAVCO. Results may not be complete or correct. This data service is not operated by the UNR Nevada Geodetic Laboratory. This is not an official service of UNAVCO." The page is powered by GSAC. Navigation links include "Search Sites", "Search Files", "Browse", "API Information", and "Help". The "Site Query" section contains a "Code (4 character ID)" input field, a "Lat-Lon Bounding Box" section with "Select" and "Clear" buttons, and a "Site occupied in date range" section with two date input fields. The "Results" section is currently empty.

Case Study: The August 24, 2014 Napa Mw6.0 Earthquake

Imagine this happens

And you want GPS solutions.

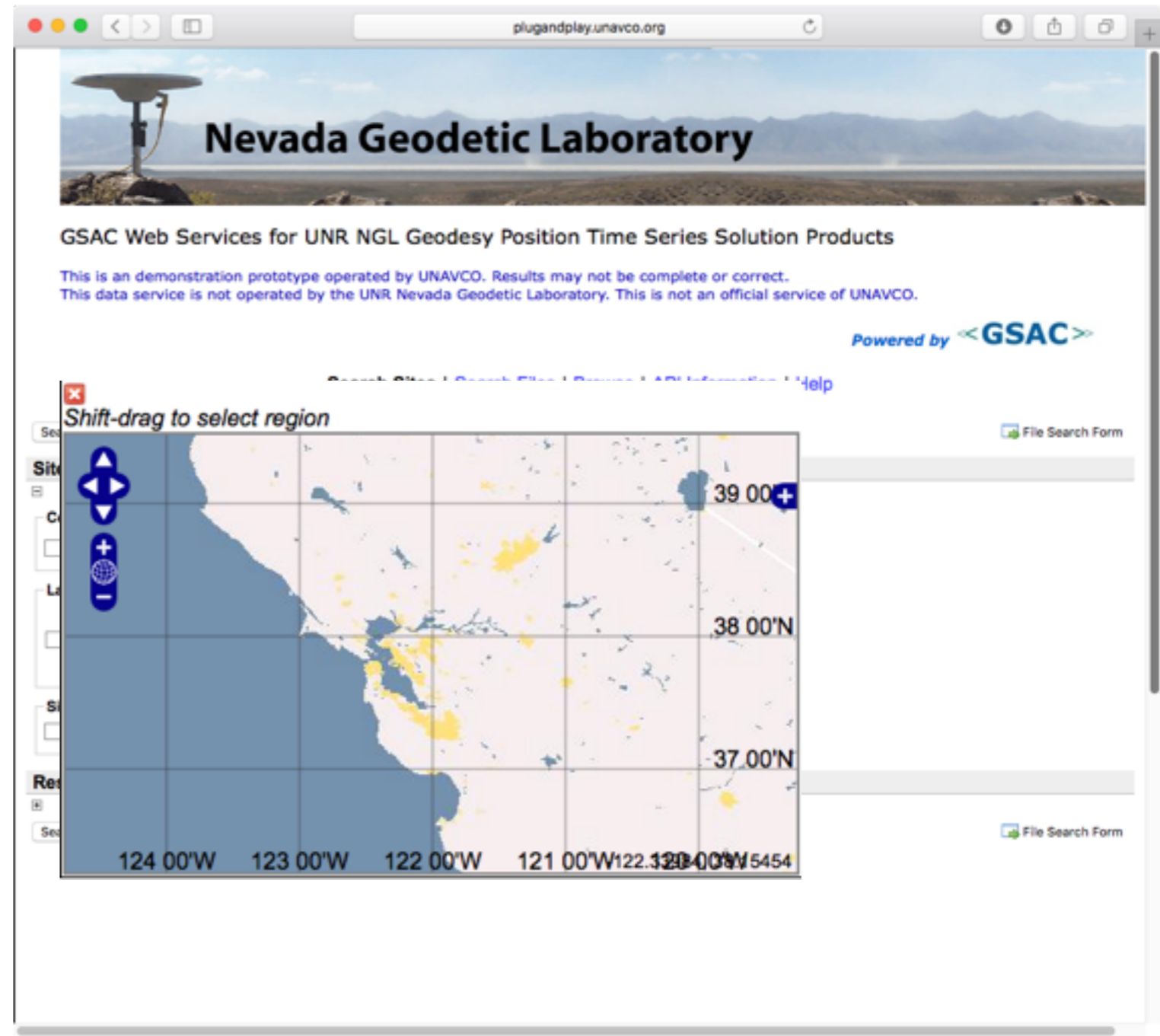
You go to <http://geodesy.unr.edu/>
You see there are many stations ...

If you want an example time series
you might want to grab a couple plots.

Hover you mouse to get station name.

Or if you want everything and you are
OK writing scripts you might try the:

- Data Holdings files...
- GSAC search tools



The screenshot shows a web browser window at plugandplay.unavco.org. The page header features a banner image of a GPS antenna with the text "Nevada Geodetic Laboratory". Below the banner, it reads "GSAC Web Services for UNR NGL Geodesy Position Time Series Solution Products". A disclaimer states: "This is an demonstration prototype operated by UNAVCO. Results may not be complete or correct. This data service is not operated by the UNR Nevada Geodetic Laboratory. This is not an official service of UNAVCO." The page is powered by GSAC. The main content area displays a map of the western United States with a grid overlay. The map shows station locations as yellow dots. A blue box highlights a region in the northwestern part of the map, with a coordinate label "39 00' N" and a plus sign. The map includes a search bar and a "File Search Form" on the right. The browser window also shows a "Shift-drag to select region" tooltip and a "Help" link.

Case Study: The August 24, 2014 Napa Mw6.0 Earthquake

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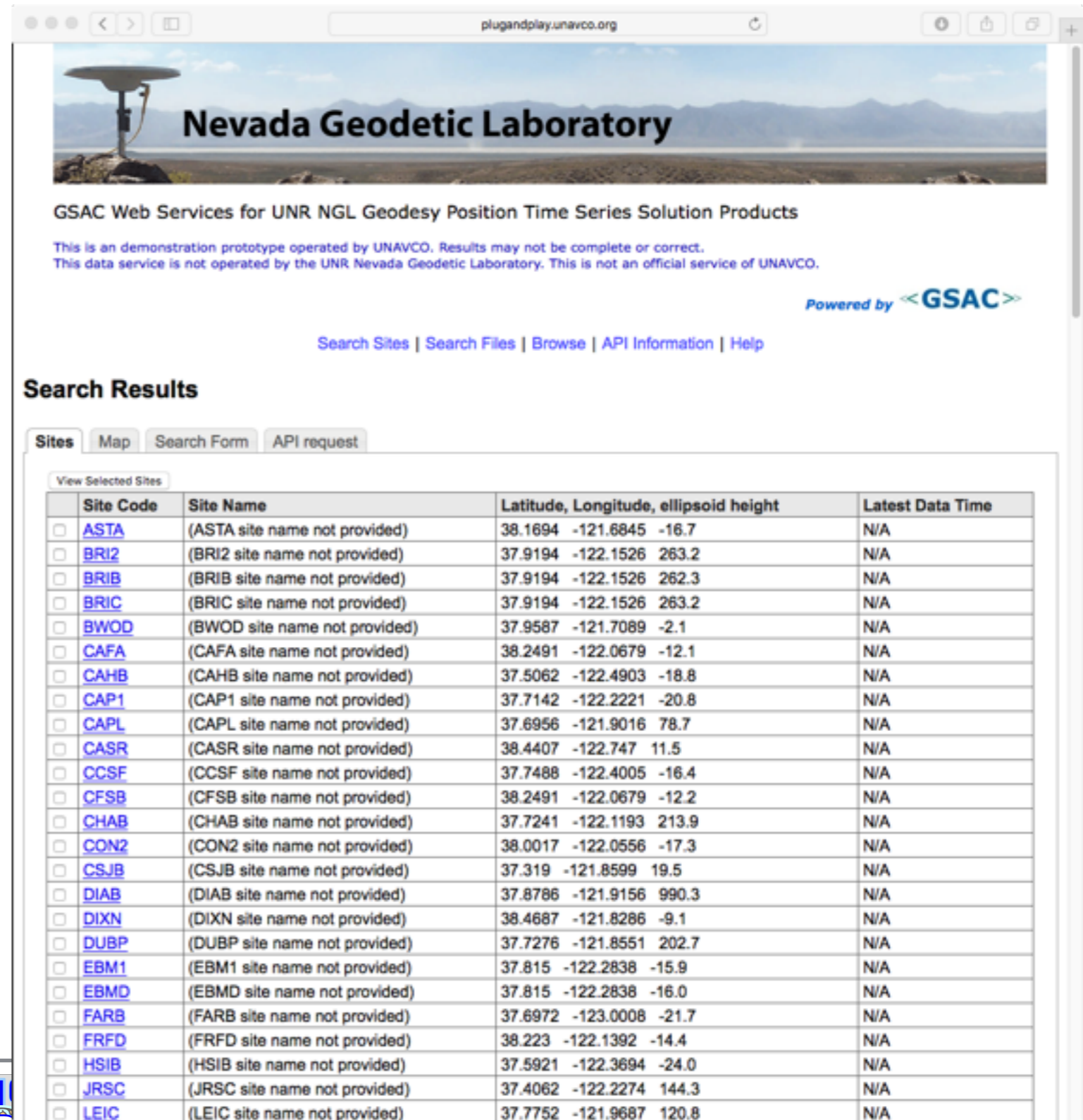
You see there are many stations ...

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Hover you mouse to get station name.

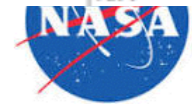
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The screenshot shows the Nevada Geodetic Laboratory website interface. The header includes the logo and title "Nevada Geodetic Laboratory". Below the header, there is a navigation menu with links for "Search Sites", "Search Files", "Browse", "API Information", and "Help". The main content area displays "Search Results" for various GPS stations. A table lists the following data:

Site Code	Site Name	Latitude, Longitude, ellipsoid height	Latest Data Time
<input type="checkbox"/> ASTA	(ASTA site name not provided)	38.1694 -121.6845 -16.7	N/A
<input type="checkbox"/> BRI2	(BRI2 site name not provided)	37.9194 -122.1526 263.2	N/A
<input type="checkbox"/> BRIB	(BRIB site name not provided)	37.9194 -122.1526 262.3	N/A
<input type="checkbox"/> BRIC	(BRIC site name not provided)	37.9194 -122.1526 263.2	N/A
<input type="checkbox"/> BWOD	(BWOD site name not provided)	37.9587 -121.7089 -2.1	N/A
<input type="checkbox"/> CAFA	(CAFA site name not provided)	38.2491 -122.0679 -12.1	N/A
<input type="checkbox"/> CAHB	(CAHB site name not provided)	37.5062 -122.4903 -18.8	N/A
<input type="checkbox"/> CAP1	(CAP1 site name not provided)	37.7142 -122.2221 -20.8	N/A
<input type="checkbox"/> CAPL	(CAPL site name not provided)	37.6956 -121.9016 78.7	N/A
<input type="checkbox"/> CASR	(CASR site name not provided)	38.4407 -122.747 11.5	N/A
<input type="checkbox"/> CCSF	(CCSF site name not provided)	37.7488 -122.4005 -16.4	N/A
<input type="checkbox"/> CFSB	(CFSB site name not provided)	38.2491 -122.0679 -12.2	N/A
<input type="checkbox"/> CHAB	(CHAB site name not provided)	37.7241 -122.1193 213.9	N/A
<input type="checkbox"/> CON2	(CON2 site name not provided)	38.0017 -122.0556 -17.3	N/A
<input type="checkbox"/> CSJB	(CSJB site name not provided)	37.319 -121.8599 19.5	N/A
<input type="checkbox"/> DIAB	(DIAB site name not provided)	37.8786 -121.9156 990.3	N/A
<input type="checkbox"/> DIXN	(DIXN site name not provided)	38.4687 -121.8286 -9.1	N/A
<input type="checkbox"/> DUBP	(DUBP site name not provided)	37.7276 -121.8551 202.7	N/A
<input type="checkbox"/> EBM1	(EBM1 site name not provided)	37.815 -122.2838 -15.9	N/A
<input type="checkbox"/> EBMD	(EBMD site name not provided)	37.815 -122.2838 -16.0	N/A
<input type="checkbox"/> FARB	(FARB site name not provided)	37.6972 -123.0008 -21.7	N/A
<input type="checkbox"/> FRFD	(FRFD site name not provided)	38.223 -122.1392 -14.4	N/A
<input type="checkbox"/> HSIB	(HSIB site name not provided)	37.5921 -122.3694 -24.0	N/A
<input type="checkbox"/> JRSC	(JRSC site name not provided)	37.4062 -122.2274 144.3	N/A
<input type="checkbox"/> LEIC	(LEIC site name not provided)	37.7752 -121.9687 120.8	N/A



Case Study: The August 24, 2014 Napa Mw6.0 Earthquake

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The screenshot shows the website plugandplay.unavco.org. The header features a banner for the Nevada Geodetic Laboratory with the text "Nevada Geodetic Laboratory" and "GSAC Web Services for UNR NGL Geodesy Position Time Series Solution Products". Below the banner, there is a disclaimer: "This is an demonstration prototype operated by UNAVCO. Results may not be complete or correct. This data service is not operated by the UNR Nevada Geodetic Laboratory. This is not an official service of UNAVCO." The page is powered by GSAC and includes navigation links for "Search Sites", "Search Files", "Browse", "API Information", and "Help". There are also buttons for "Search Files" and "Wget Script for FTP download".

The "File Query" section contains several search criteria:

- Data Date Range:** Two input fields with a double-headed arrow between them.
- Publish Date:** Two input fields with a double-headed arrow between them.
- Data Type:** A dropdown menu with options: "--Any-", "Final Daily time series", "Rapid 5 minute time series", and "Rapid Daily time series".
- Data File Format:** A dropdown menu with options: "--Any-", "UNR kernv 5 min", "UNR krms RMS products", and "UNR qa file".
- Data Reference Frame:** Radio buttons for "FID", "IGS08", "NA12", and "TRF unknown".

The "Site Query" section is currently empty. Below it, the "Results" section shows a table of station data:

Station	Site Name	Latitude	Longitude	Height	Agency
<input type="checkbox"/> JRSC	(JRSC site name not provided)	37.4062	-122.2274	144.3	N/A
<input type="checkbox"/> LEIC	(LEIC site name not provided)	37.7752	-121.9687	120.8	N/A



Case Study: The August 24, 2014 Napa Mw6.0 Earthquake

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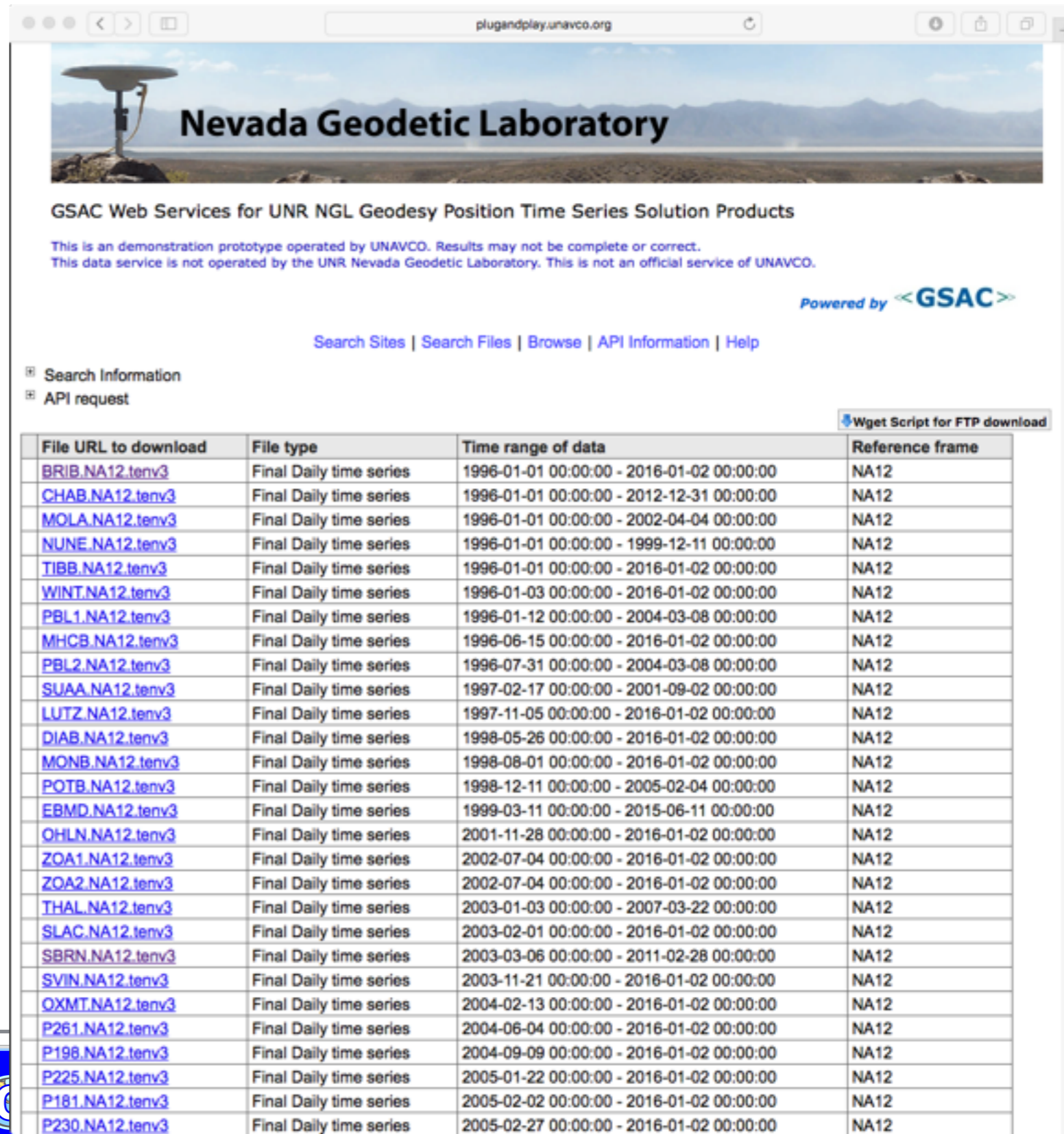
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Hover you mouse to get station name.

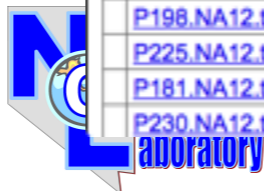
Or if you want everything and you are OK writing scripts you might try the:

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- GSAC search tools



The screenshot shows the Nevada Geodetic Laboratory website. The header includes the title "Nevada Geodetic Laboratory" and the text "GSAC Web Services for UNR NGL Geodesy Position Time Series Solution Products". Below the header, there is a navigation menu with links for "Search Sites", "Search Files", "Browse", "API Information", and "Help". A table of station data is displayed, with columns for "File URL to download", "File type", "Time range of data", and "Reference frame". The table lists 30 stations, each with a unique file URL and a time range. A "Wget Script for FTP download" button is visible at the top right of the table.

File URL to download	File type	Time range of data	Reference frame
BRIB.NA12.tenv3	Final Daily time series	1996-01-01 00:00:00 - 2016-01-02 00:00:00	NA12
CHAB.NA12.tenv3	Final Daily time series	1996-01-01 00:00:00 - 2012-12-31 00:00:00	NA12
MOLA.NA12.tenv3	Final Daily time series	1996-01-01 00:00:00 - 2002-04-04 00:00:00	NA12
NUNE.NA12.tenv3	Final Daily time series	1996-01-01 00:00:00 - 1999-12-11 00:00:00	NA12
TIBB.NA12.tenv3	Final Daily time series	1996-01-01 00:00:00 - 2016-01-02 00:00:00	NA12
WINT.NA12.tenv3	Final Daily time series	1996-01-03 00:00:00 - 2016-01-02 00:00:00	NA12
PBL1.NA12.tenv3	Final Daily time series	1996-01-12 00:00:00 - 2004-03-08 00:00:00	NA12
MHCB.NA12.tenv3	Final Daily time series	1996-06-15 00:00:00 - 2016-01-02 00:00:00	NA12
PBL2.NA12.tenv3	Final Daily time series	1996-07-31 00:00:00 - 2004-03-08 00:00:00	NA12
SUAA.NA12.tenv3	Final Daily time series	1997-02-17 00:00:00 - 2001-09-02 00:00:00	NA12
LUTZ.NA12.tenv3	Final Daily time series	1997-11-05 00:00:00 - 2016-01-02 00:00:00	NA12
DIAB.NA12.tenv3	Final Daily time series	1998-05-26 00:00:00 - 2016-01-02 00:00:00	NA12
MONB.NA12.tenv3	Final Daily time series	1998-08-01 00:00:00 - 2016-01-02 00:00:00	NA12
POTB.NA12.tenv3	Final Daily time series	1998-12-11 00:00:00 - 2005-02-04 00:00:00	NA12
EBMD.NA12.tenv3	Final Daily time series	1999-03-11 00:00:00 - 2015-06-11 00:00:00	NA12
OHLN.NA12.tenv3	Final Daily time series	2001-11-28 00:00:00 - 2016-01-02 00:00:00	NA12
ZOA1.NA12.tenv3	Final Daily time series	2002-07-04 00:00:00 - 2016-01-02 00:00:00	NA12
ZOA2.NA12.tenv3	Final Daily time series	2002-07-04 00:00:00 - 2016-01-02 00:00:00	NA12
THAL.NA12.tenv3	Final Daily time series	2003-01-03 00:00:00 - 2007-03-22 00:00:00	NA12
SLAC.NA12.tenv3	Final Daily time series	2003-02-01 00:00:00 - 2016-01-02 00:00:00	NA12
SBRN.NA12.tenv3	Final Daily time series	2003-03-06 00:00:00 - 2011-02-28 00:00:00	NA12
SVIN.NA12.tenv3	Final Daily time series	2003-11-21 00:00:00 - 2016-01-02 00:00:00	NA12
OXMT.NA12.tenv3	Final Daily time series	2004-02-13 00:00:00 - 2016-01-02 00:00:00	NA12
P261.NA12.tenv3	Final Daily time series	2004-06-04 00:00:00 - 2016-01-02 00:00:00	NA12
P198.NA12.tenv3	Final Daily time series	2004-09-09 00:00:00 - 2016-01-02 00:00:00	NA12
P225.NA12.tenv3	Final Daily time series	2005-01-22 00:00:00 - 2016-01-02 00:00:00	NA12
P181.NA12.tenv3	Final Daily time series	2005-02-02 00:00:00 - 2016-01-02 00:00:00	NA12
P230.NA12.tenv3	Final Daily time series	2005-02-27 00:00:00 - 2016-01-02 00:00:00	NA12

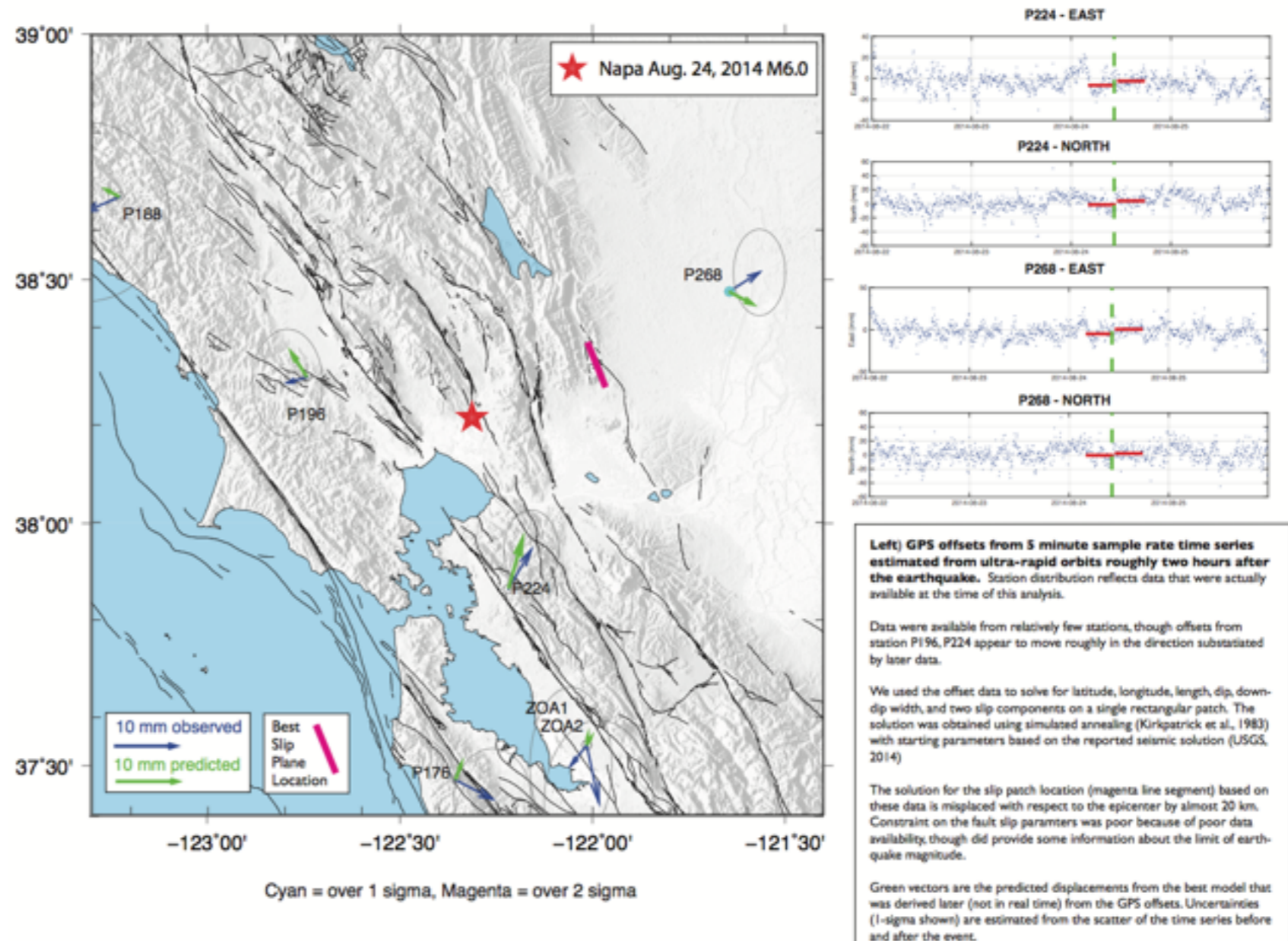


Case Study: The August 24, 2014 Napa Mw6.0 Earthquake

Two Hours After Event: Ultrarapid Orbits

- Not “real time” i.e. 1 Hz with 1 s latency
- From Hourly RINEX
- Not all stations providing hourly
- Working on that
- Offsets detected
- But uncertainties are large
- Inferred source poorly constrained

Earthquake Displacements from 5 Minute Sample Rate Time Series



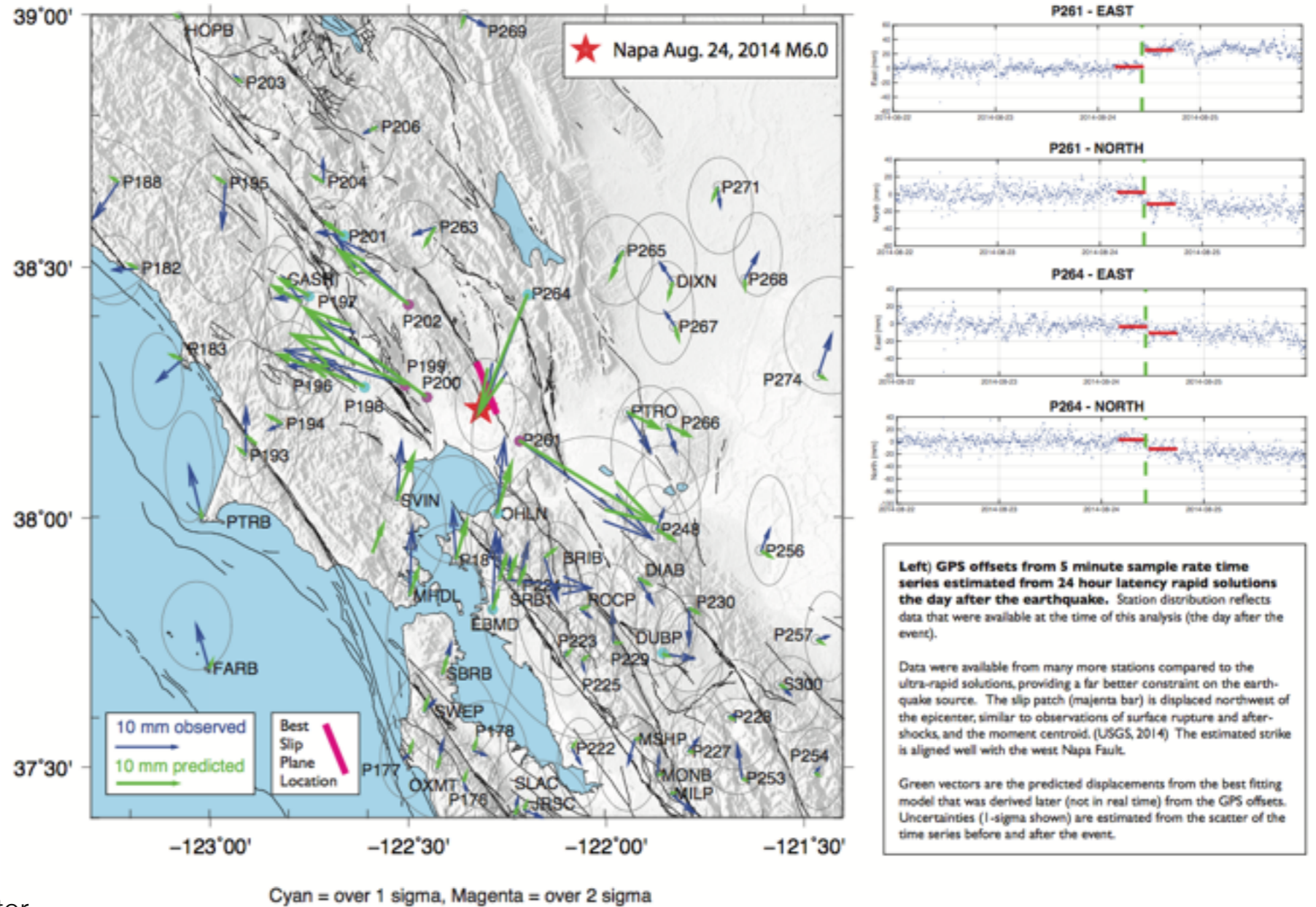
from Hammond et al., 2014 Fall AGU poster

Case Study: The August 24, 2014 Napa M_w6.0 Earthquake

Next Day After Event: Rapid Orbits

- Many more stations contributing
- Time series better behaved
- Offsets show clear strike-slip character
- Significant offsets as far as e.g. south Bay Area
- Source location, style, slip better constrained
- Extent of significant displacement from earthquake more clear

Earthquake Displacements from 5 Minute Sample Rate Time Series



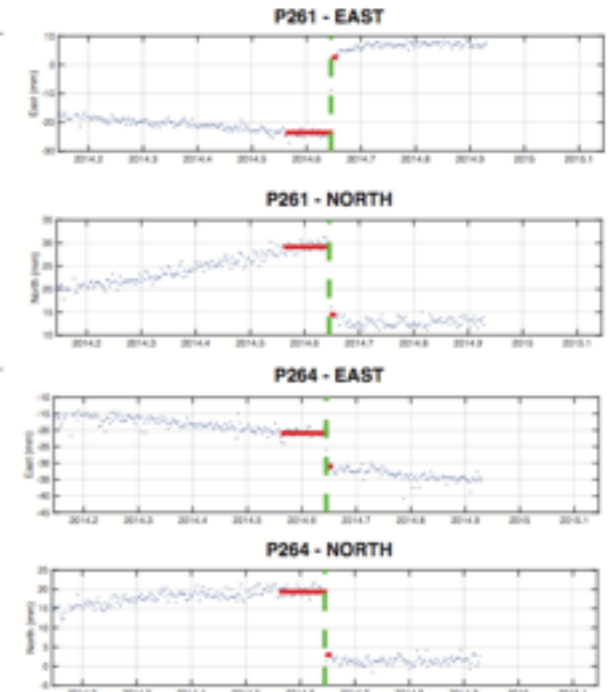
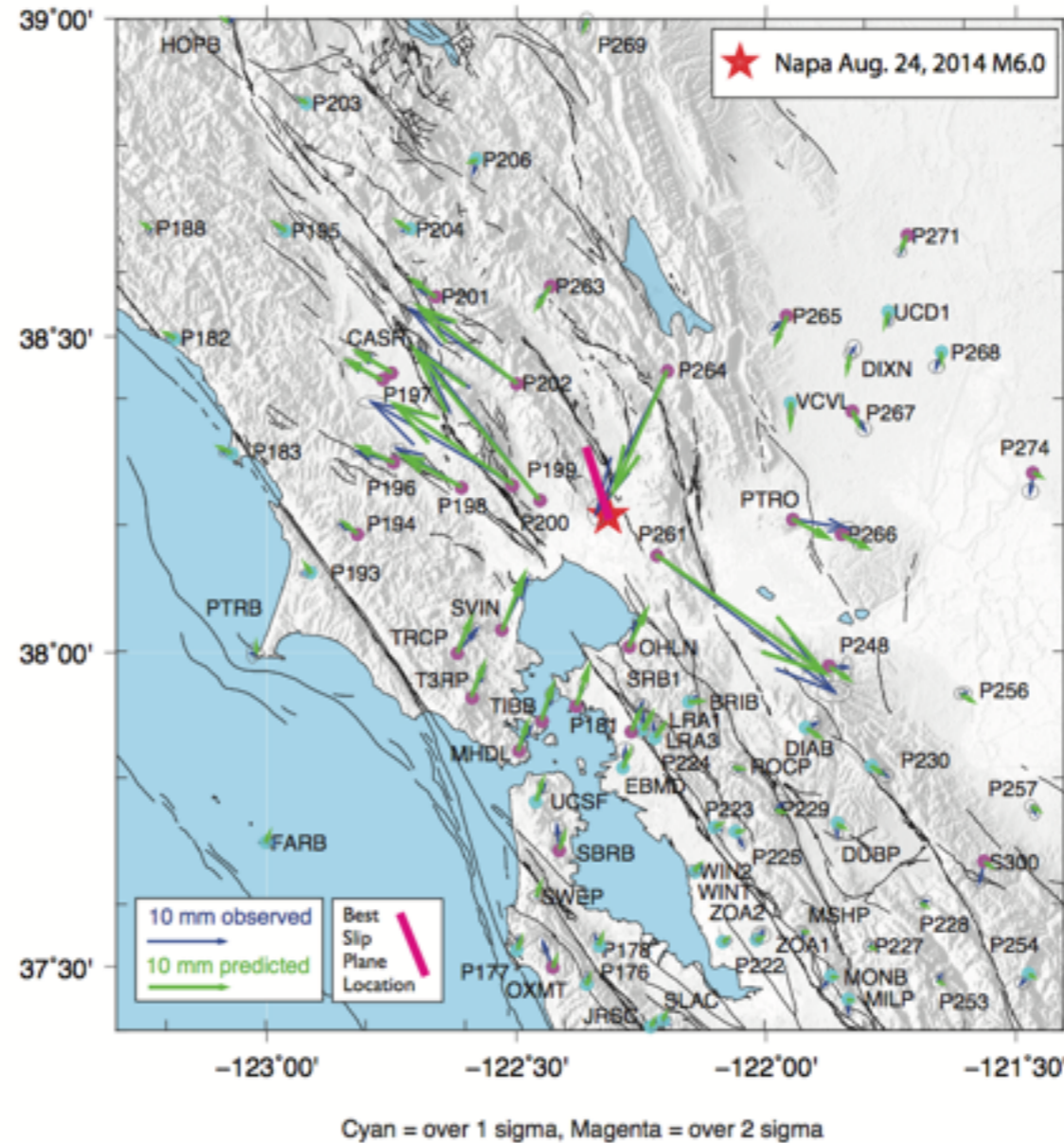
from Hammond et al., 2014 Fall AGU poster

Case Study: The August 24, 2014 Napa M_w6.0 Earthquake

1 Full GPS Day Later: Rapid orbits

- Time series greatly improved, reduced scatter from 24 hour sample rate solutions
- Offsets better constrained
- Dramatically smaller uncertainties
- Inferred source right on top of seismic epicenter

Earthquake Displacements from 24 Hour Sample Rate Time Series



Left) GPS offsets from 24 hour sample rate time series estimated from rapid orbits. These results were available after one full GPS day transpired after the earthquake. The offset is the difference between position during the first full day after the event and the mean of 30 days prior to the event. Station distribution reflects data that were actually available at the time of this analysis.

Compared to the 5 minute sample rate time series, a greater number of GPS stations have provided data and the uncertainties in the displacements are far smaller.

The maximum displacements (29 mm) were at station P261. Marin County moved between 4 and 10 mm northeast.

The model slip patch is located in a similar location compared to the rapid 5 minute solutions, ~5 km northwest of the epicenter. This slip patch is in a similar location to the seismogeodetic solution of Melgar et al., 2014 (see their poster in this session).

Green vectors are the predicted displacements from the best fitting model that was derived later (not in real time) from the GPS offsets. Uncertainties (1-sigma shown) are estimated from the scatter of the time series before and after the event.

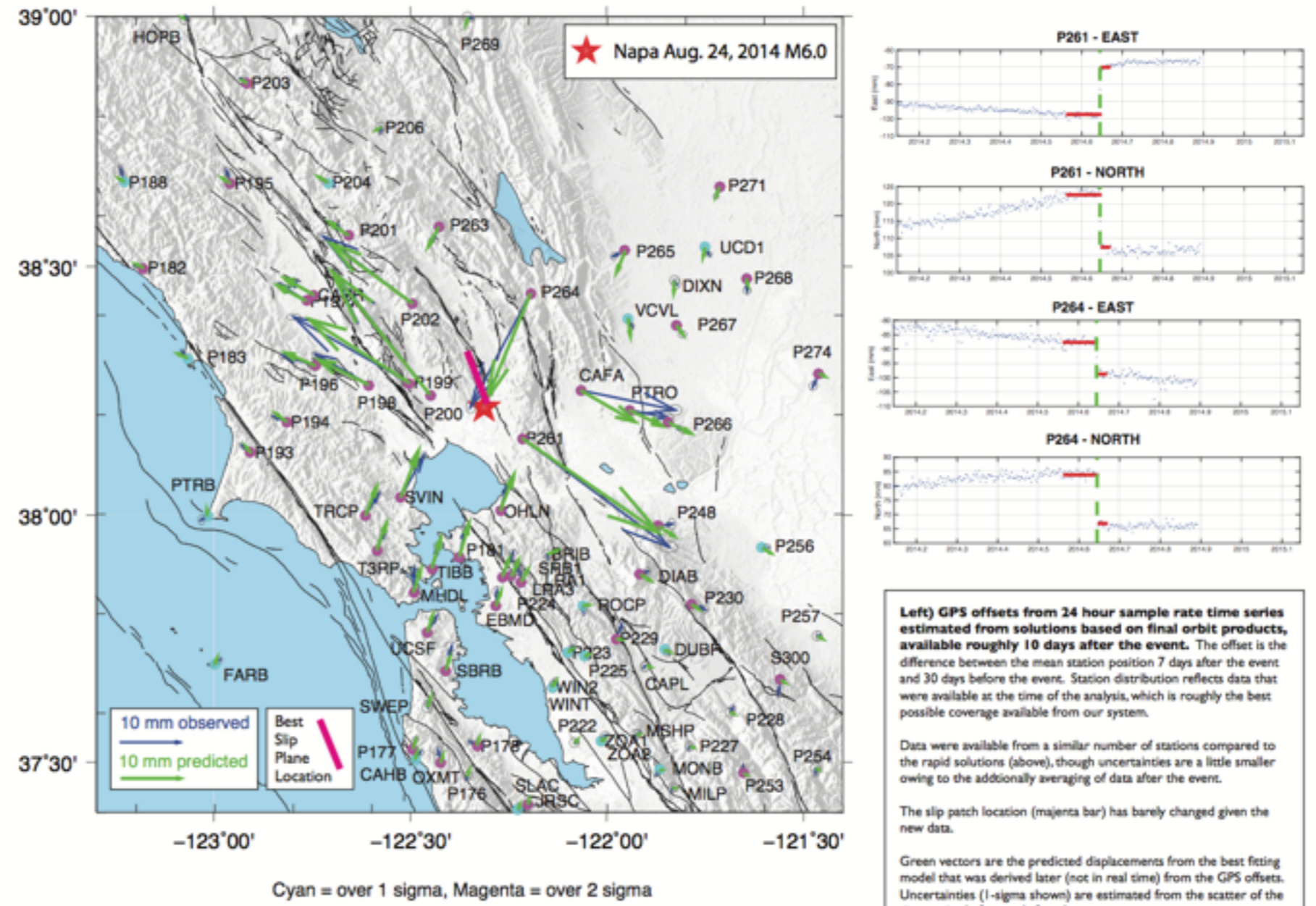
from Hammond et al., 2014 Fall AGU poster

Case Study: The August 24, 2014 Napa M_w6.0 Earthquake

10 Days After Event: Final Orbits

- Moderate improvement over rapids
- Shows stability in solution of source
- Similarity to seismic slip inversions
- Used to benchmark real-time source inversion studies, e.g. Melgar et al., 2015 JGR plus other groups used our rapid-offsets

Earthquake Displacements from 24 Hour Sample Rate Time Series



from Hammond et al., 2014 Fall AGU poster

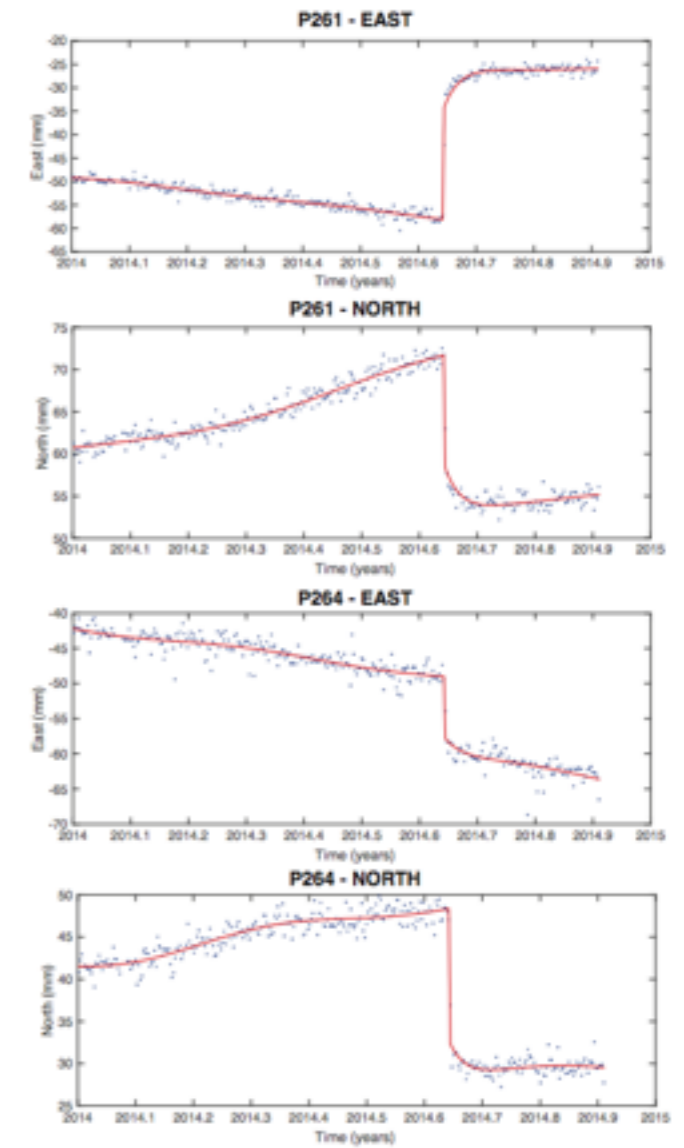
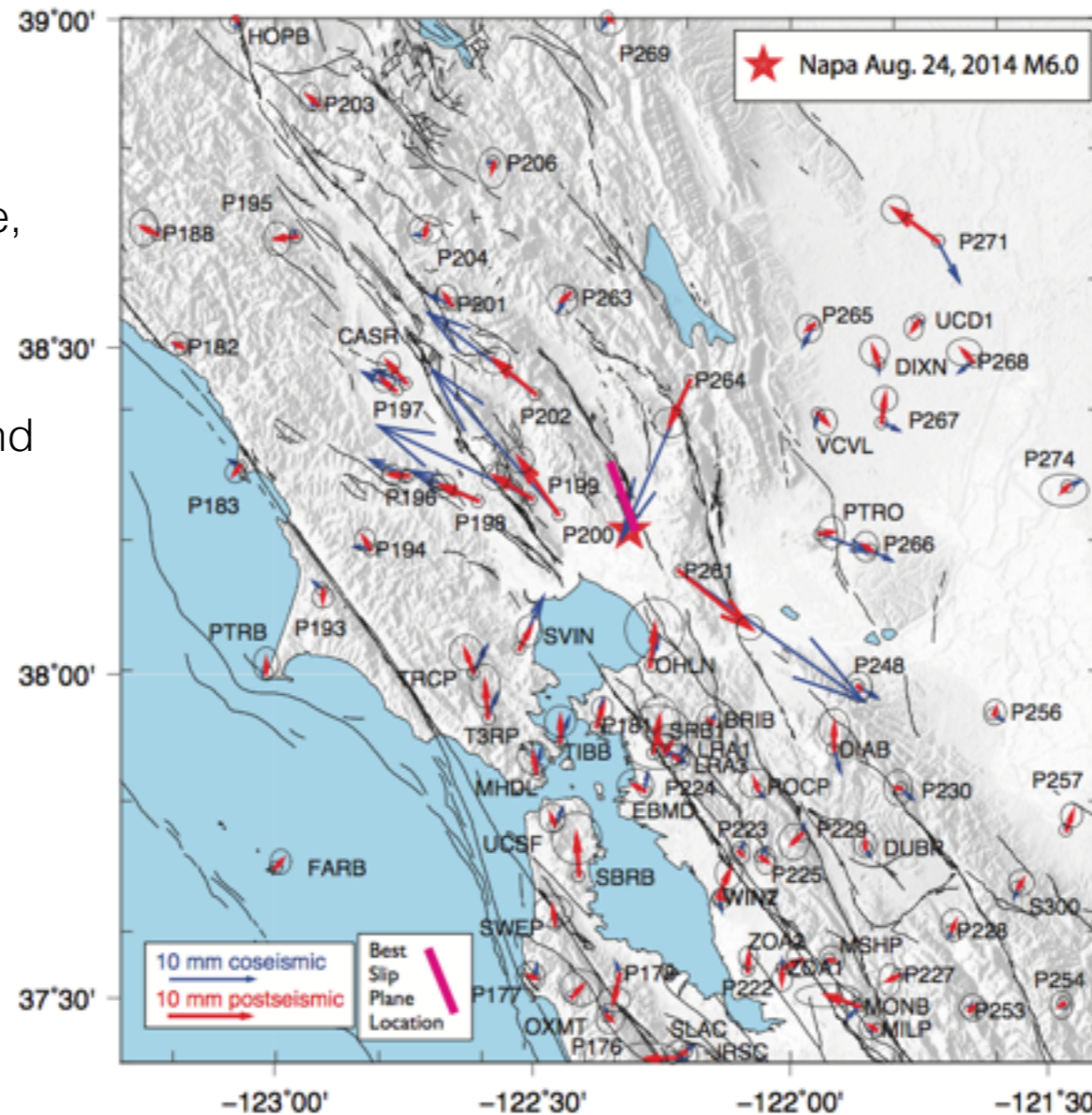


Case Study: The August 24, 2014 Napa Mw6.0 Earthquake

Months After Event: Final Orbits

Postseismic Displacements from 24 Hour Sample Rate Time Series

- Time series modeled with slope, intercept, annual+semiannual terms, step, exponential decay after event
- Clear postseismic afterslip found
- Seen in GPS data and in situ surface observations
- Lasted weeks
- Coseismic $M_W=6.07$ versus postseismic $M_W=5.75$
- Clear implications for seismic hazard studies



from Hammond et al., 2014 Fall AGU poster

Case Study: The August 24, 2014 Napa $M_w6.0$ Earthquake

Conclusions

- This has been an demonstration of the utility of the Plug and Play system
- Napa earthquake shows how well and how quickly we can do low latency earthquake geodesy
- This example in a tectonically active area with a dense network of continuously recording GPS stations
- Future plans include extending service to automatically and systematically provide offsets (coseismic displacements) for every event over M 5.0.
- In the interim you will need to model steps from time series yourself.

More information on Napa earthquake offsets

<http://geodesy.unr.edu/billhammond/earthquakes/nc72282711/nc72282711.html>



Case Study: The August 24, 2014 Napa Mw6.0 Earthquake

Thank you for attending!

