WSRN – Frequently Asked Questions

In the order of most frequently asked:

Contents

I can't connect, have my logins been turned off?

No, unless it is an expired test account period. Otherwise, the WSRN never disables logins without contacting the user directly beforehand. A rare reason for disabling is an unpaid invoice, but even then, we do not disable it without direct contact first. The exception is the free 90-day test accounts; those automatically disable after 90 days. If you attempt a login with an incorrect password 10 times, it may lock. In that case, contact us immediately and we can do a reset. If you still cannot log in, it is likely due to reasons other than your login credentials.

I can't connect, is there something going on with the network today?

Very rare. Network outages are rare but can happen for various reasons. For such contingencies, we operate redundant systems that are identical without any differences in performance. The user can switch to another server and caster at any time. The quickest way to see if there is an issue with either system is to go to the respective web pages: www.wsrn.org or www.wsrn3.org and open the sensor map. You do not need to log in to the webpage to see the sensor map, but you could log in to test your logins. It is a good practice to instruct your crews on how to switch from one caster to another.

Are you doing maintenance on the system right now?

System maintenance and updates are done after hours, and typically on weekends (e.g., monthly security patches). If there is a major upgrade planned that could take one of the redundant servers offline for many hours, we send notices a month in advance via the user email list (for those who opt-in to receive email notices). For whatever reason that a server might be down (individual server uptime is over 98%) it is extremely unlikely that both would be down at the same time. Make sure your crews know how to switch casters when they need to (See the recommended presets section towards the end of this list).

My logins are OK, and the network looks OK, why can't I connect?

This is almost always related to cellular service. It can be frustrating as you may see bars on your phone, voice works OK, and it may have worked OK on a different day, but that does not necessarily mean that data is steaming well enough where you are at that time. One easy check

is to open a browser on your field data collector and navigate to a website (choose one that changes a lot as you may see a cached page otherwise). Another tool is a cell status app, like Network Cell Info Lite, that shows the signal strength in detail (for instance, a value of -100 dBm – 110 dBm often means spotty data streaming, and -110(+) dBm can mean no data streaming). Even though you show bars and have voice, the data streaming may be spotty or not flowing. iPhone users can also view a native analysis tool by cutting/pasting or typing *3001#12345#* into the phone dialer; this will show much the same info as the app mentioned above.

I forgot my username and/or password, can you give them to me again?

Please keep a copy of your credentials email handy and give one to your crews. And it's always good practice to test your gear before going to the field. We can help if you are stuck in the field and forgot your password, but it might take some time. With many thousands of logins, we have to look them up, and now that there are new security protocols applied, we can't even see the passwords in the system. We look at secure copies of the original credential emails we sent you. If we are in the field or otherwise out of the office when you call or email, we may give you a temporary login (that automatically expires in a few days) in the interim until we can look up your credentials and re-email them to you.

Can solar storms mess up my results?

During this peak year of the current solar cycle, there will be some very-GPS-unfriendly days. Such days are intense, inconvenient, but infrequent. Being prepared can minimize the impact on your productivity. In short, GNSS users, whether they are using the WSRN or not, should heed the solar storm warnings and evaluate the performance of their rovers. Theses step can help users make decisions about field operations during "bad solar" days. We've provided some links on the WSRN website that should help.

Background

We are experiencing the peak of Solar Cycle 25 (the 25th since solar cycles were first recorded. The rocky times are expected to extend through 2025 and into early 2026. While this solar cycle peak may not be any worse than previous ones, there have already been some significant periods of intense geomagnetic activity. Plus, people are much more dependent on GNSS than during the previous cycle.

You see online posts and news about Aurora Borealis activity viewable in places that normally do not see it (a sure sign of rough solar periods).

Rather than rehash much of the background, read this article: [Preparing for the Effects of Solar Cycle 25 on GNSS Applications](#). In the months since that article was published, we've compared notes with RTN operators and GNSS developers who have monitoring arrays. An analysis of data feedback from several solar storms has helped us develop some recommendations for how to prepare for and minimize the effects of solar events.
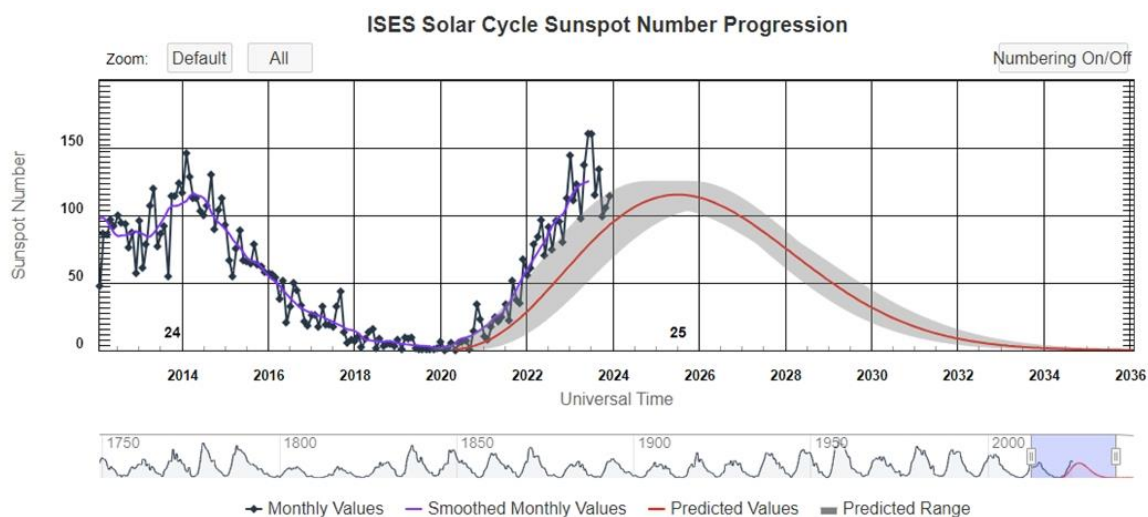
Solar Cycle 25. Sunspot counts are a key indicator of increased solar activity

Analyzing a Solar Event

The May 10, 2024, Gannon Geomagnetic Storm, was the most significant since the Halloween storms of 2003. In terms of high-precision GNSS, here are a few things we learned from the analysis.

1. Not all GNSS rovers were affected in the same way. Some saw only slower fixes; others experienced no fixes and/or terrible residuals.
2. Multi-constellation, implemented on both the base (or RTN) and rover, rode out the storm far better than single constellation gear. The former, especially newer gear with the solar activity measures manufacturers have recently added, typically continued to operate just fine. Users may have experienced slightly slower fixes, but residuals were mostly acceptable.

3. Older rovers struggled, or were not useable, though most of this may be due to being limited to single, or dual constellations.
4. Low cost and DIY rovers, as well as some drones that utilize similar low-cost GNSS boards, were significantly affected during the solar storms.
5. Post-processing does not help; if the base data for a period is affected by the solar storm, then no amount of post-processing can help.

There were, of course, certain exceptions. During such solar storms, the effects of scintillation can be exacerbated. So, even top-performing rovers, that were otherwise riding out the storm just fine, may have experienced brief periods of intense effects. And there were users who experienced cellular connectivity and radio issues.

Expected Effects*

Geo Magnetic Storm Scale.	Kp Index	Local I-95 Index	Level	GNSS Effects
G5	9	16>	Extreme	No GNSS, possibly no cell or radio
G4	8	>16 <12	Severe	GNSS unlikely, possibly limited cell or radio
G3	7	>12 <8	Strong	Older, low priced, and 1-2 constellation-only rovers will likely not work. Certain newer, multi-constellation rovers might work, but with Slow fixes and residuals likely poor
G2	6	>8 <4	Moderate	Slow fixes and sub-optimal residuals possible. May not affect certain rovers.
G1	5	>4 <2	Minor	Normal conditions for most rovers. Some older, low-end, and 1-2 constellation rovers may experience slow fixes.
0	<5	<2	Negligible	Normal conditions, no effects

*As results can vary for different rovers, you should check how yours performs at different Kp Index and I95 Index levels.

There are, of course, certain exceptions. Scintillation is happening all the time, even during the Solar Minimum. It is typified by intense, local, and often brief periods of elevated space weather conditions. During solar storms, the effects of scintillation can be exacerbated. So, even top-performing rovers that were otherwise riding out the storm just fine, may have experienced brief periods of intense effects. And some users also experienced cellular connectivity and radio issues.

Heed the Warnings

You probably see the frequent, seemingly daily, news bits about "the biggest solar storm ever". Or you may have subscribed to an email list for solar warnings. The problem is that the sometimes-confusing terminology and various index conventions these sources present do not provide a GNSS rover user with a scale that they can relate to exactly what to expect in the field.

While there is an index developed specifically for GNSS, the I-95 ionospheric index, it is not a predictive resource. It can still be very useful for users to better correlate with the scales presented by the predictive resources. More on I-95 later.

The other challenge of space weather resources and their predictions is that these are expressed mostly in terms of global levels, and may or may not reflect what is happening, or could happen in your specific vicinity. For instance, how does a global G2 storm warning equate to a KP index level for North America?

Fortunately, for different regions of the world, prediction resources are more locally focused. In North America, the National Oceanic and Atmospheric Administration (NOAA) provides a 3-day predictive tool that is expressed in the KP scale. Check this index daily; it is a link on the WSRN websites. Reconsider send your crew out to survey on the other side of the state on what is predicted to be a 7+ Kp day. Packing a backup, say a total station, during the solar peak is a good idea.

CURRENT SPACE WEATHER CONDITIONS on NOAA Scales

3-DAY FORECAST

```
:Product: 3-Day Forecast
:Issued: 2024 Oct 17 1230 UTC
# Prepared by the U.S. Dept. of Commerce, NOAA, Space Weather Prediction Center
#
A. NOAA Geomagnetic Activity Observation and Forecast

The greatest observed 3 hr Kp over the past 24 hours was 3 (below NOAA
Scale levels).
The greatest expected 3 hr Kp for Oct 17-Oct 19 2024 is 4.00 (below NOAA
Scale levels).

NOAA Kp index breakdown Oct 17-Oct 19 2024

              Oct 17      Oct 18      Oct 19
00-03UT       3.33        2.67        4.00
03-06UT       3.00        3.00        3.67
06-09UT       2.00        2.00        3.33
09-12UT       1.67        2.00        2.67
12-15UT       2.00        3.00        2.00
15-18UT       2.00        3.33        2.00
18-21UT       2.33        3.67        2.67
21-00UT       3.00        4.00        3.00

Rationale: No G1 (Minor) or greater geomagnetic storms are expected.  No
significant transient or recurrent solar wind features are forecast.
```

Example of a NOAA 3-day forecast

For instance, a G1 storm might be KP3 or 4, and G2 might bring KP 6+—which is when you might start seeing effects. There are some other prediction resources from vendors like Leica and others.

NOAA Scales Geomagnetic Storms

Kp < 5	Kp = 5 (G1)	Kp = 6 (G2)	Kp = 7 (G3)	Kp = 8, 9- (G4)	Kp = 9o (G5)

NOAA has a 27-day prediction tool that can give you a rough idea, but it is best to check again with the 3-day tool.
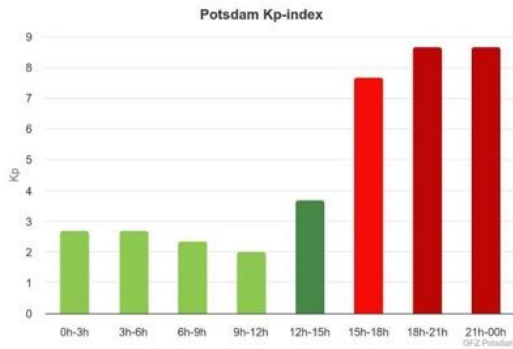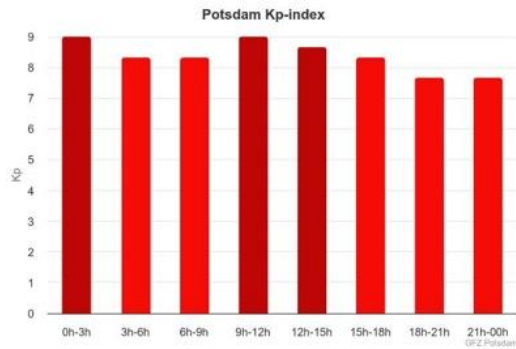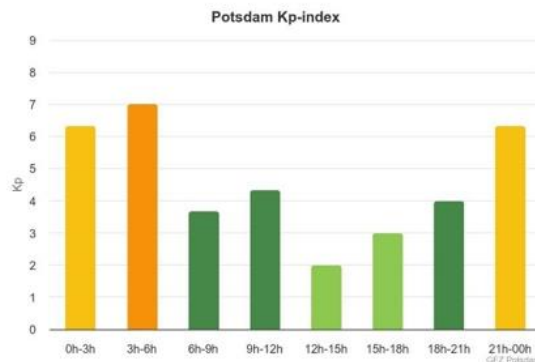
Example of a Kp index plot of the May 2024 solar storm

A KP of over 7 is a significant event, and you could (depending on your gear) see slow fixes, poor residuals, no fixes, terrible residuals, or even no GNSS at all.

Here is where the I95 index could be very handy. I-95 is calculated by many local, state, or regional Real-time networks (RTN) using data from their fixed stations. The WSRN computes I95 values, from WSRN stations, for each subnet, updated at the top of each hour. You can see current conditions, and go back several weeks, but it is not a predictive tool. It is handy to check if you suspect current solar conditions are disrupting your field operations, or to analyze past field session.

http://www.wsrn.org/MemberPages/Ionosphere.aspx
htttp://www.wsrn3.org/MemberPages/Ionosphere.aspx

I-95 is often expressed in units of expected, uncorrected error (centimeters) and/or color-coded levels.
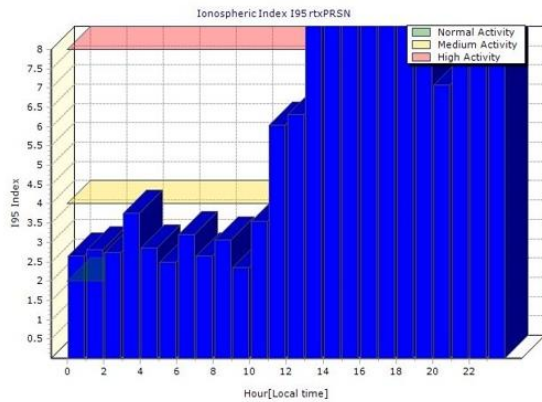
Friday, May 10, 2024 - PM   Saturday, May 11, 2024 - AM
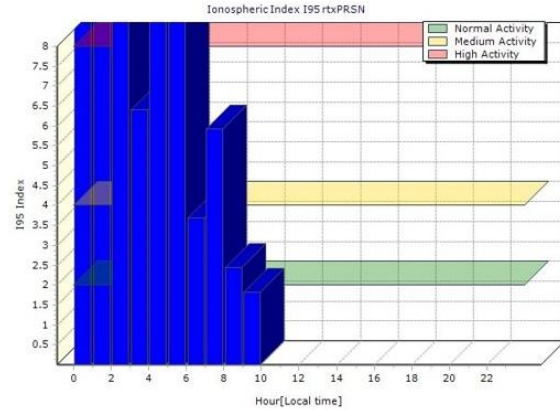
Example of locally observed I95 during the May 2024 solar storm. This example is from the PRSN subnet of the WSRN

During rough solar days, users can begin to develop rules of thumb for their gear, by looking at observed Kp levels and locally observed I95 levels. Then you can correlate these with what your gear experienced at different levels. This can make forecast scales more useful in planning your fieldwork.

The color coding of the I95 graphs: Green=Calm, no effects. Yellow=Moderate, minor effects, like slightly slower fixes. Red=High, this is where various rover types can experience slow fixes ,to no fixes, to poor residuals, to no solutions.

Updating and Upgrading

This linked article includes some detail about what GNSS rover manufacturers have done, since the last solar peak, to help mitigate the effects of solar storms. In some cases, the features were only practical on newer, multi-constellation rovers (with a lot of processing power). In some cases, a firmware update (for newer gear) activates it. But for older gear, with limited satellites and processing resources, there is no option for this.

It is a reality that low-cost rovers generally will not fare well during solar storms. Drone work can also be challenging and frustrating during bad solar days. Many (even some of the most popular) drones have small, light, and relatively inexpensive GNSS boards. There are very popular, low-cost GNSS (and GNSS+IMU) boards developed for the nascent autonomy market that are quite appealing to drone manufacturers. Some firms have even taken the same boards and made rovers out of them (some via DIY kits). This is all great under optimal conditions, but

perhaps it is not wise to try to use these during bad solar days. Most of the calls we get from WSRN users during solar storms are from those with low-cost or older rovers, and some drone users.

A note about single base operations: if you do single base on one day with calm ionospheric conditions, you may get different results than on a day of high ionospheric activity. Network corrections, like VRS, are often the better choice, but neither will have much luck if in the red. There are hazards to mixing solutions: If you start a project with one method, you may get different results when switching baseline lengths or on different iono status days.

Intense and Inconvenient but Infrequent

So far, in 2024, we've recorded a dozen rough solar days. Fortunately, half of these fell on weekends (pure luck). The prospects of a no-go day about once a month might not impact the operations of some users much, but it can be a serious proposition for others.

But don't fall into the "vibe-ospheric" trap. Yes, we are in the peak of a solar cycle, and it casts a bad vibe over field operations—but you should not blame everything on it. You might be having comms issues, settings issues, bad multipath, or another issue you should troubleshoot. Instead, some users blame it all on the sun.

In short, we could be in for several years where the potential for detrimental space weather effects could be heightened on occasion. However, with today's modern equipment, you may only experience issues when the values are "in the red".

What can I do in a poor cell environment?

You are at the mercy of the cellular coverage, and it might be poor in that area all the time, and somewhat usable on other days or different times of the day. The cell coverage maps from the main carriers are not always accurate but can give you a general idea. The carriers have been rapidly upgrading their systems and coverage. Some apps show cell tower locations and what carriers are on each tower. If you have a built-in modem, see if you have the option of connecting an external cell antenna. It is hard to keep up with which carrier works best in which region of the state; that continues to evolve. The WSRN has no map of cell coverage; the situation moves too fast, and it is impractical to try to comprehensively test across the state. We

rely on feedback from users, and some note that they can now get cell service in areas they could not even a few years ago.

We do get asked if there are ways to improve the signals, like with boosters. From feedback from users: some carry phones/modems for two or more carriers if they work in multiple areas across the state. Some users who use their phone as a hotspot or have a portable WiFi hotspot will put those on a telescoping rod to get some elevation; it is surprising how an extra 10' can improve cell reception in some places. Some WiFi hotspots come with an external antenna jack (SMA coax connector). There are large dipole cell antennas, and directional (yagi-style), that you can point at the nearest cell tower). Adding a booster to the mix may not help: if you have RF 'garbage' coming in, the booster may just amplify the 'garbage'. In marginal cell areas, a booster can help, but it can be hit-or-miss. The in-line boosters work better than proximity-style boosters. An effective booster can cost hundreds of dollars and needs its own power source. We use in-line boosters for many of the reference stations, but those are fixed locations where we test and set up the right antenna for the location.

We have tested a last resort option for spotty cell areas: switch to single base (but there are trade-offs). The reason this might work is that single base does not require consistent bi-directional communications with our caster like VRS does; a single base solution is a request that starts the flow, and if there are gaps in the flow, your rover will simply wait until it has enough data. The one big caveat is that if you are in an area with poor cell, there is likely not a reference station nearby, and the long-baseline, single-base solution may be poor quality and inconsistent.

A key recommendation from users who encounter poor/no cell areas: collect static and or PPK and post-process or use one of the commercial precise point positioning (PPP) services that broadcast from L-Band satellites (lower precision, especially in the vertical, but good in a pinch). The WSRN has a post-processing service for static observations (not PPK), for account holders; see more below.

My positions are off by several feet, what's up?

Another common support call is when the user sees values off by about 4 feet horizontally. This is a datum transformation issue. GPS/GNSS is referenced to WGS/IGS/ITRF, and the values you typically want to work in are NAD-based (i.e., the current national reference framework).

NSAD83 and WGS/IGS/ITRF are identical ellipsoids but separated by separated by about 2m at the center of the earth, which means different separations around the globe. For the US, the NGS chose to use this shifted ellipsoid as it was felt (at the time) that it would fit the plate better. However, after the upcoming datum change, the two will again be the same.
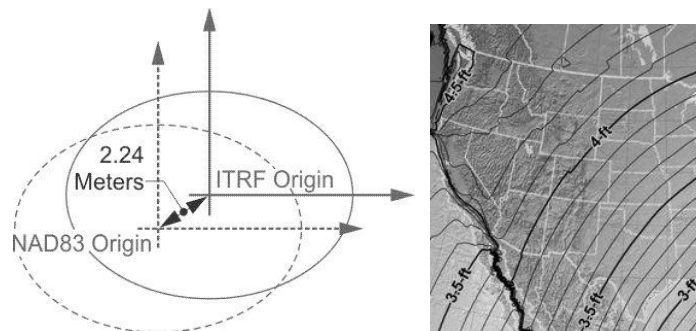
NAD83 differs from the global reference, in WA, about 4 feet. Your software does the transformation on the fly (if you have the right settings). After the pending datum change, there will be no difference.

Fortunately, your field software does a transformation on the fly (i.e., the Molodensky transformation). If this is not working right, the issue is in your settings. The WSRN is constrained to NAD83-2011, and in some brands of field software you have to choose "No transformation" or you will be double transforming, which is about 4 feet in horizontally. For example, in some Topcon field software, you choose "No Transformation", and in some Trimble software you choose "NAD83" and not "NAD83-2011". Consult with your equipment vendor on this. If your orthometric elevation values are off between 60-80 feet, that indicates that a geoid model is not being applied in your field software. Again, consult with your equipment vendor.

My positions, compared to published control values are off by several tenths, what's up?

The Earth is dynamic. Differences may be due to the age of the published values, and/or the methods used to establish them. Due to plate velocities, for example, a position in the Seattle area may have changed by half a foot over 25 years. Published values may have been

established with legacy methods, or legacy reference frameworks that do not have the same network accuracy as more recent ones. Plus, the marks may have been set 50 or 60 years ago, and there may be many reasons why they might be suspect. We suggest doing check shots on recently published NGS or WSDOT marks that have NAD83-2011 values. You may wish to use a "localization" or "calibration" (it is called different things in different vendors' field software) routine if you need to constrain your project to old, published values.

What datum, or reference frame does the WSRN work in?

The WSRN constrains all reference stations to the National Spatial Reference Framework (NSRS) of the National Geodetic Survey (NGS). Currently, this is NAD83-2011 Epoch 2010.00. Vertically, WSRN stations are also NSRS, expressed as ellipsoid heights. Orthometric elevations, like NGVD88 are derived in your field or office software by applying a geoid separation model, For instance, GEOID 2018 from the NGS. We recommend using whatever the latest geoid model is from the NGS. You can obtain the geoid files from the NGS or your GNSS rover vendor.

Does the WSRN provide me with State Plane Coordinates?

No, the WSRN works purely in geographic references. Any plane projections are done in your field or office software. Again, talk to your vendor about how to set that up in your field software.

Does the WSRN provide grid or ground?

No. Again, this is all handled in your field or office software.

Does the WSRN provide low-distortion projections (LDPs)?

Again, those are projections that would be handled in your field or office software. To date, Washington State has not developed or adopted LDPs, though an ad hoc committee in WA has requested a placeholder for LDPs with the NGS, but firm plans and funding to develop them have not been finalized. If and when LDPs for WA are developed, the NGS will provide the definitions to the manufacturers and then you will likely see them in your field or office software. In Oregon, the Department of Transportation (ODOT) developed LDPs covering the highway

corridors, and ODOT also operates its state RTN, but the two functions are not directly related per se.

What hardware and software are needed to use the WSRN?

You need a high-precision GPS/GNSS receiver and antenna, either in the form of a standard "rover", or other receiver and antenna combinations. The receiver needs to be capable of using external corrections and can track at least GPS satellites, or multiple constellations (e.g., combinations of GPS, GLN, GAL, BDS, etc.). To receive corrections from the WSRN you will need internet connectivity, typically via a cellular connection. You will need field software that supports your GPS/GNSS hardware, it will also need to support NTRIP connections (see the NTRIP section below).

You have to set up a cell connection with a cellular carrier directly (the WSRN does not do this) I.e., use a modem or phone with a data plan. Some rovers have a modem built into the rover head, others have a modem in the field data controller, and other users work via an app on a phone. Some users prefer a portable WiFi "hotspot", and connect their controller to it via WiFi, while others use their phone as a hotspot. In any scenario, you need to have a data plan with a cell carrier. Nearly all field software or apps for surveying/mapping are set up for NTRIP protocols. If it does not, there are free apps that can receive corrections and pass them to a receiver, but you will still need a cellular data plan. See the NTRIP section below.

Can you recommend hardware and software?

No, we are prohibited from recommending or endorsing any products. Nearly all rovers made in the past 20 years can use services like the WSRN. There are some common protocols and formats offered by all RTNs globally, and there is nothing inherent in what an RTN offers that would be advantageous or disadvantageous for any brand or model. There are a few RTNs (out of many hundreds) that only provide proprietary formats. The WSRN offers common non-proprietary services. However, depending on the age of a rover, and what constellations of satellites and signals the rover supports, you would choose different flavors of corrections. For example: we broadcast multiple correction flavors (standard formats) for each station, and subnet (e.g., RTCM3.1, RTCM3.2_MSM, CMR+) because there are some users with older gear that cannot use newer formats. See the multi-constellation section below for those broadcast

correction types and mount point naming conventions. Contact us if you are unsure, though your equipment dealer should tell you the format your gear supports, as well as the equipment data sheet.

The same applies to field software. We can discuss rovers and software generically. The feedback we receive from users and testing is that nearly all newer gear can achieve similar results. Shop around.

What do you mean by VRS and single base?

VRS is a type of network RTK (NRTK) that uses data from multiple stations surrounding where you are working and creates corrections modeled for your location to send corrections as if you have a base right next to you with a near-zero baseline length. There are several types of NTRK, like MAC/MAX (master auxiliary approach), and FKP. Years ago, we offered the other formats but found that users did not use them and have settled on VRS. The differences in results were not significant, and we found that we could achieve better station spacing with VRS.

Keep in mind that the "virtual" in VRS is a bit of a misnomer. It refers to the corrections derived from the surrounding stations, but there is also a direct relationship to a physical reference. Typically, the nearest station in the VRS solution is the source of reference coordinates. For VRS solutions, this physical base link can be found in different field software under the name PRS (physical reference station) or PBS (physical base station). You can export (in your field software) as vectors from the PBS/PRS for inclusion in post-processing, the same as with vectors from single bases.

Single base is where differential-style corrections are from one individual station. One drawback of single base is that results degrade over distance, typically at distances of 10km or more, though it may be possible to get fixes with 30-50km baselines (if conditions are optimal). Real-time networks globally found that NRTK allowed for much greater station spacing; it would be impractical to be able to afford to build a network with 10km spacing. With NRTK they can be spaced at 30km-70km (depending on local conditions). That was the impetus for developing network corrections for RTN.

Can I receive WSRN corrections with my rover radio?

Not directly. With the limited range of radios, it would be impractical to set up enough base radios to cover large areas (i.e., we'd have to put up over 1500+ base radios to cover the state). Some users though use a modem to receive corrections from the WSRN and rebroadcast them via base radio, or use various types of RTK bridges. This approach is employed, for instance, for some construction sites.

Can you help me set up my rover?

In short, no. While we will try to help, we are not versed in every hardware/software combination, and that is more rightly the responsibility of the vendor that sold you the rover, through whatever support arrangement you have with them. When you receive login credentials from us via email when you first start working with the WSRN, it includes the key things you will need to put in the settings of your field data collector software, like caster address, and port. In general, you look for any screen in your software that has keywords like 'NTRIP' or 'caster'.

Through years of support calls, we may have a general idea of what different manufacturers call different settings in their software and will try to help if we can, but the best bet for settings help is to ask the vendor first. If the vendor gives you the new gear with the settings preset, we recommend you go over those (in detail) with them. Becoming familiar with the settings, and how to change them if needed, can help avoid getting stuck in the field trying to figure things out. Like if someone has changed your settings, or if you need to change them for other reasons.

Where do I find the current positions of the stations (e.g., for post-processing)?

You can go to the sensor map and click on any station, then choose the info tab. That will list the live NAD83-2011 Epoch 2010.00 position and ellipsoid height of the antenna reference point (ARP) of the station. Users may need this if they are doing their own post-processing. We also provide links for IGS/NGS-style site logs (abbreviated), a PDF info sheet, KMZ, and CSV of all stations through the 'Reference Framework' page on our website. Further explained:

<u>Working with base coordinates for post-processing.</u>

For post-processing applications, like static sessions (e.g. for control) and post-processed Kinematic (PPK, e.g. for drones or mobile mapping). The WSRN provides base coordinates in several different formats.

All base coordinates in the WSRN are constrained to the national Spatial Reference Framework System (NSRS) per the U.S. National Geodetic Survey. NADS83-2011 Epoch 20210.00 (with new coordinates for the pending NATRF datum, sometime in 2026, when implemented by the NGS). See more about this on page 13. WSRN stations are either an NGS CORS or constrained to the NGS CORS.

There are multiple options for finding individual base coordinates, lists, sitelogs, KML, and delimited files (csv). Again, these are all <u>NAD83-2011 Epoch 2010.00.</u>

These are expressed in <u>geographic coordinates</u> (i.e. latitudes, longitudes, and ellipsoid heights) or <u>cartesian</u> (global xyz). Note that cartesian coordinates are a x, y, and z ordinates originating at the earth's center. Both can be used by your surveying office software. GPS essentially works in cartesian but is expressed as geographic + ellipsoid height in the software. You will likely never work directly in Cartesian, as geographic is much easier to work with in end uses. <u>The "z" in Cartesian is not directly related to elevation or height</u>, it is the ordinate from the earth's center in the direction of the polar axis. The "x" and "y" axis are at right angles to the "z" axis. The diagram below shows the two conventions:
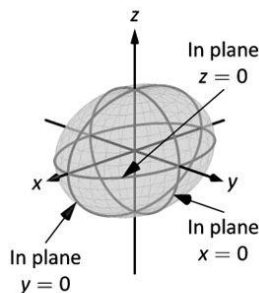
You do not have to worry about any of this, except that some sources for coordinates that your software can use may be expressed in one way or the other.

<u>Common coordinate formats, and how to access these from the WSRN:</u>

Comma Delimited - Geographic (decimal degrees) and Cartesian:

www.wsrn.org/CONTENT/Coords/WSRN_DecDeg.csv

For example:

# Created at 2025-01-30	file format v1.1													
# Station ID	Unique ID	Station co	X	Y	Z	Latitude	Longitude	Height	Antenna h	Name	Station name	Manufacturer	Receiver Name	Receiver Firmware Version	Receiver Serial Number
6	94	SSHO	-2299720.293	-3635669.338	4693221.895	47.68229547	-122.3151477	74.455	0	TRM115000.00 NONE	SSHO	TRIMBLE	TRIMBLE ALLOY	Nav 6.23 / Boot 5.63	6016R40079

Some office software prefers a .csv for station coordinates and data.

KML - Keyhole Markup Language – Geographic (decimal degrees):

www.wsrn.org/CONTENT/Sitelogs/WSRN_Stations.kml

KML also has the station info and decimal degree coordinates. This can be imported into Google Earth, and various office software.

For example:
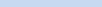
```
        <Placemark>
            <name>SSHO</name>
            <description>
StationCode = SSHO
StationID = 6
StationName = SSHO
Receiver = TRIMBLE ALLOY
Firmware = Nav 6.23 / Boot 5.63
SerialNo = 6016R40079
Antenna = TRM115000.00     NONE
            </description>
        <styleUrl>#msn_wht-blank0</styleUrl>
            <Point>
                <coordinates>-122.3151,47.6823,74.455</coordinates>
            </Point>
        </Placemark>
```

PDF List - Geographic (ddd-mm-ss.ssss):

www.wsrn.org/CONTENT/Coords/NAD83-2011_WSRNCoords.pdf

This is handy printable list of station data and coordinates, and there is an abbreviated mountpoint naming convention on the last page.

For example:

			WSRN Coordinates - NAD83-2011 Epoch 2010.00 Coordinates Currently Applied to WSRN Stations											
													30-Jan-25	
Site Name	Site #	Location	Coords Update	Lat	LatM	LatS	Lng	LngM	LngS	EllipHt	Calc Source	Antenna		Receiver
SSHO	6	North Seattle WA	10/13/2020	47	40	56.26370	122	18	54.53169	74.455	NGS CORS	TRM115000.00	NONE	Alloy

Sitelogs – Cartesian: www.wsrn.org/CONTENT/Sitelogs

Each station has a current IGS (International GNSS Service) format sitelog. Most geo software (e.g., survey office software) can import these for the base data alike receiver and antenna types. While the coordinates section state "approximate", the WSRN sitelogs have current NAD83-2011 Epoch 2010.00 coordinates. The file extension is .log (but you can view in Notepad++ etc.)

For example:

```
     SSHO Site Information Form (site log)

1.   Site Identification of the GNSS Monument

     Site Name ............... : SSHO
     Four Character ID ....... : SSHO
     Monument Inscription .... :
     IERS DOMES Number ....... :
     CDP Number .............. :

2.   Site Location Information

     City or Town ........... :
     State or Province ...... :
     Country ............... :
     Tectonic Plate ......... : North America
     Approximate Position (ITRF)
       X coordinate (m) ..... : -2299720.2927
       Y coordinate (m) ..... : -3635669.3383
       Z coordinate (m) ..... : 4693221.8949
```

Note that these are space delimited and if you try to edit, make sure you account for every space.

Rinex Headers – Cartesian

If you open a Rinex file (e.g., with Notepad++) you'll see the Cartesian Coordinates underneath the antenna type. Note that in a standard Rinex file, that line is reserved for approximate coordinates. However, if exported from the WSRN, we've put the current base ARP coordinates there. Also, note that the antenna height is always zero, as the reference point (as with NGS CORS and Bluebooked marks) is the antenna reference point (ARP) i.e., where the bottom of the antenna contacts the mount.

```
     3.04           OBSERVATION DATA    M (MIXED)           RINEX VERSION / TYPE
TPP                 Reference Data Shop 20250130 151052 UTC PGM / RUN BY / DATE
SSHO                                                        MARKER NAME
SSHO                                                        MARKER NUMBER
WSRN                Washington State Reference Network      OBSERVER / AGENCY
                    TRIMBLE ALLOY                           REC # / TYPE / VERS
                    TRM115000.00    NONE                    ANT # / TYPE
 -2299720.2927  -3635669.3383   4693221.8949               APPROX POSITION XYZ
        0.0000         0.0000         0.0000                ANTENNA: DELTA H/E/N
G   40 C1C C1W L1C L1W D1C D1W S1C S1W C2P C2W C2S C2L C2X  SYS / # / OBS TYPES
```

Additional note about base antenna heights. No matter how tall the base antenna mount is (pillar, drill-brace, building mount, etc.) the position is the ARP. If you look at the drawings that are published for antenna model calibrations (e.g., from the NGS: www.ngs.noaa.gov/ANTCAL/) it notes the ARP as the reference point (not the phase center). You only worry about measure-ups for your own antennas.

What do the different color dots on the web map indicate?

On the live sensor map, green indicates that the station is connected and in solution. Yellow indicates that we may have a connection, but that there may be an issue with data completeness, spotty comms, or data quality and that it does not presently meet standards for inclusion in the solution. Red means we have lost connection altogether for the time being.

Why is that station down?

Stations might be down for various reasons, mostly comms, or weather in the winter. For instance, station SC03, on top of Mount Olympus, can be down for weeks at a time in winter (deep snow over the solar panels). Most often with sites, an outage can be attributed be spotty comms that usually get better in a matter of hours or a day. We can remotely fix many issues, but sometimes we have to plan a trip to the site to see what is up. Fortunately, even if individual stations are down, the network solution (VRS) is usually still fine—another reason why RTN was developed.

Is the WSRN multi-constellation?

Yes. All but two WSRN stations are four-constellation: GPS (U.S. Navstar), Glonass (GLN), Galileo (GAL), and Beidou (BDS). Plus, on the coast, some of the satellites from the QZSS constellation can be seen during different periods of the day. The exception is two of the stations built and operated by the scientific community that are GPS-only: P025 and P422. We will exclude these from VRS solutions until they are upgraded (and we have no idea when they will do that), but they are available for single-base and static files.

While all but those few stations are multi-constellation, new signals on some of the constellations have only gone live in recent years, so we are in another phase of station upgrades to take advantage of newer signals. We studied logs of usage and started this latest phase of upgrades based on areas of high usage, like the Puget Sound Region, Spokane, Tri-Cities, Vancouver WA/SW region, and larger cities. We are on track for a full upgrade within the next 2 years.

What does 'MSM' mean?

This means 'multi-system message', a term used for RTCM corrections that support multiple constellations. We use MSM as a suffix for any of our mountpoints that provide RTCM3.2-MSM corrections, a format that nearly all newer rovers can use. This is the format we recommend users of newer gear use so they can take advantage of as many satellites and signals as possible.

How can I try out the WSRN?

The WSRN recommends all new users use a (one-time) test account, that is free for 90 days, to make sure the service will work for their needs. The login provided automatically expires after 90 days. To request a test account simply send an email with your street address, company name (if applicable), primary contact name and email, and best phone number to get ahold of you. And tell us what day you would like the test to start. Please give us a day or two to set this up.

The login page for the WSRN asks for an 'Organization', what is my 'Organization'?

The organization is the group or type of account you have. When you receive your WSRN credentials via email it will state your organization. For example, subscribers are in the org 'SUBS', partners in 'PARTNERS", schools and academia are in 'EDU', scientific entities are in 'SCIENCE', WSDOT is 'WSDOT', and test accounts are in 'TEST". Some other large entities have their own Org (we send that to them when they get issued credentials).

How do I get Rinex files for post-processing?

There are two ways to get static files for post-processing. One is directly from the WSRN websites, and the other is from an academic long-term archive.

The WSRN logs (1 second) hourly static files from all stations locally (on both redundant systems), and also in a long-term archive. These are openly made available to anyone. If you are looking for static files within the past 55 days, you can use the 'Reference Data Shop'. Log in to the website (with your credentials or as a guest) and look for that option in the upper left. You create a request, choose one or more stations, a time period, the type of static file you

want, and sample rate. Orders must be specified in GPS time, which is (for ordering purposes) the same as Greenwich Mean Time (GMT). That is 7 or 8 hours different from local WA time depending on the time of year.

Note your order numbers. It may take a while to process the order (usually 5 minutes to an hour depending on how much you order), but you can log in later and see your order status. Never pick the email option (this is disabled due to potential file size issues)—choose the download option. When the order is ready you will see a download link; it will download as a single .zip file.

For static files older than 55 days, you need to go to the [archive at CWU/PANGA](#), where the files are kept indefinitely, though they may decimate them after a few years to 15-sec or 30-sec to save file space. However, for the first year or so, you should be able to get 1-Sec files. Choose the year, and then the [Julian Date](#), then the sample rate you want (e.g., 1-Sec, 5-Sec, etc.) You will see files listed by station prefix. The observations are in ".bz2" files (e.g., 'cblv038i.23d.bz2'0.

To save space (they are archiving a tremendous amount of data), CWU compresses the files twice. The".bz2" files can be unzipped by nearly all zip utilities. Once you've unzipped a ".bz2" file you will see a file with a "XXd" extension (e.g., 'cblv038i.23d'). That is 'Hatanaka' compressed, a program developed specifically for GPS/GNSS observations in Rinex format. [Download the 'CRX2RNX.exe' converter](#). Then you can right-click the "d" file and 'open with' that executable. Many surveying office software packages will decompress those as well, though you can do the two-step decompression as described above. It sounds like a pain, but remember, in the early days of GPS we had many more hoops to jump through, and this is free Rinex data.

What is Virtual Rinex?

Another option in the "Reference Data Shop' is Virtual Rinex. Using the same network (VRS) processing in our system, a static file is modeled from 6-9 stations around a location you specify on the order page. Other than picking a 'virtual' location it is the same steps as a regular static data order (see above). Once processed, it will show a download link of a .zip of the single Rinex file. It will post-process just like any other Rinex.

Virtual Rinex was developed to be able to reduce the length of static sessions, though with as many satellites as there are now, it is not used as much as in the past. There has been a resurgence of use more recently, with UAS (drone) operators finding it can be a good option in some situations for PPK post-processing.

Please note: the storage of the specific data needed to create virtual Rinex is very resource intensive, therefore **we only keep the source files for two days**. If you plan to order Virtual Rinex, please do so within two days of your fieldwork.

What is NTRIP?

You will likely see this term in the settings of your field data collector software. NTRIP is 'Network Transport of RTCM over Internet Protocol'. It is an international standard for accessing real-time network (RTN) data. It was created decades ago by the BKG (German geodetic and mapping agency), when RTN was first developed, and adopted by the international Radio Technical Commission for Maritime Services (RTCM) 104 committee. The core code has been adopted by GPS/GNSS manufacturers. NTRIP consists of 'casters', like those of the WSRN and all RTN hosts, that allow multiple users to access multiple 'sources', or 'mountpoints'. One analogy for NTRIP is that it is like an app that connects to a web service listing many steaming music or video channels: but with GNSS corrections instead.

The other component of NTRIP is the 'client'; the software in your field controller is the client. Required settings are a caster (typically an I.P. address of a caster), a port (e.g., '8080' for the WSRN), a username and password, and you choose a mountpoint. See our mountpoint naming convention guide. Often, the field software builds a list of mountpoints each time you access the caster, in some software you need to manually refresh the list. Depending on the software, if you choose single-base or network (e.g., VRS) you will see different lists. In some, you all of the many hundreds of mountpoints.

Why are there so many different mountpoints on the list?

We need to offer different flavors (standard formats) of corrections to serve a wide range of rovers, new and old. For instance, CMR+ (GPS+GLN) for some older rovers, RTCM3.1

(GPS+GLN) for other older rovers, and RTCM3.2-MSM (GPS+GLN+GAL+BDS+QZSS) for newer, multi-constellation rovers. We do not typically have CMRx mountpoints but can do those on request if needed (though 'MSM' mountpoints support the same sats and signals). You would not see any significant difference between results from any of the formats, except that some support more satellites. See our mountpoint [naming convention guide](#).

So, for 170+ stations, and 6 VRS subnets, with 3-4 formats supported each, that adds up to a very long mountpoint list. One frustration is that the original NTRIP code does not do alphabetical order. However, many of the field software manufacturers give you an option to list them in alphabetical order once the list is refreshed. Otherwise, keep scrolling and you'll find it eventually. Note that if you refresh when a particular station is down, it will exclude it, and you might need to refresh the list later, when it is back up.

I can't connect, am I being jammed?

The short answer is no. Things like jamming, interference, and spoofing are extremely rare in our state. We have only verified a handful of instances in the 20+ years the WSRN has been operating. Examples are mostly related to altimeter radar at the end of large runways; it only happens when that is turned on for a plane to land, it is brief, and it simply blanks out any GPS/GNSS reception. Another was near a large naval facility on the peninsula, though that was brief, and over a decade ago. Working under high-power transmission lines is usually OK, but there have been some rare occasions where it messes up the cell and GPS/GNSS signals. Deliberate jamming is rare and usually occurs only in combat zones. Even in those instances, it is very localized, focused, and mostly brief.

Other RF interference is rare, and there are no persistent areas of interference in our state that we have been able to verify. Interference, when it is present, would mostly result in a denial of service, and not a false position. A map of persistent interference/jamming zones is [gpsjam.org](#). Incidents of suspected GPS issues should be reported to the U.S. Coast Guard Navigation Center: [NAVCEN](#) and investigated by multiple federal agencies. Spoofing is when a party deliberately overrides signals to create false positions. It is rare, difficult to do, and would result in values being many miles off, and not just a few tenths.

There are signal jammers like the cheap "trucker jammers" that some people have used to jam their on-board GPS to block being tracked. This is very rare and highly illegal, and only a few cases have been confirmed (nationwide). Plus, the vehicle with the jammer is moving and you might not even notice the few epochs of outage as it passes by.

We have spectrum analyzers on many of our reference stations (and have never seen any persistent interference). Plus, we have some portable devices, so we can investigate areas of suspected interference if need be.

Is single base better than VRS?

It definitely can be, but only under very specific conditions. Otherwise, single base degrades over distance. If you have a site base (that you can see from the rover, or under a km), or a station within a few km, that may yield better results than VRS on good iono days but may vary from day to day. One rule of thumb is to not use single base if you are more than 10km from a station or base. For single base to work best, the base must be set up in as good, or better, sky conditions than the rover, with low multipath conditions, and it has to support the same constellations as the rover—and it does not get stolen.

It is possible (yet not recommended) to get fixed results from single base at very long baseline lengths, 20km, 30km, and more. We have experimented (just for fun) with getting fixes from Spokane to Seattle (but would never, ever recommend this). The problem is that you will not get consistent results at long baseline lengths as the conditions could vary from day to day, even hour to hour.

Contrary to some marketing-driven rumors from the early days of RTN, VRS does include a physical base station (PBS or PRS); code is in all VRS corrections. The model of the corrections is virtual, but there is still a tie to a fixed station. Nearly every rover that can export vectors can export the rover-PBS vector.

When I connect to VRS, sometimes I see fewer satellites, why is this?

It depends on the age of your rover. There are new sats and signals that were only implemented in the past few years. An older rover may not be able to utilize all of the sats and signals it

"sees". In legacy VRS/MAC/FKP solutions, it would cull out some satellites that were not fixing, to create the corrections. Your rover would likely not use bypassed sats for the same reason. And your rover needs to use satellites that are in common with 6-9 surrounding stations.

However, in April 2023 we implemented a new feature that includes more satellites for ranging, even if they are not among the fixed ones used in modeling the corrections. While this does not degrade results, it may not necessarily improve results. However, some tests and user feedback have shown that it can improve quality and completeness, in certain situations that may have been challenging in the past, with limited satellites. Like in some sky-view-challenged locations. In short, you now use more of the sats you see in your solutions (for newer rovers).

How will the deprecation of the U.S. Survey Foot affect the WSRN?

No. Any projection to plane coordinates and feet units is performed in your field and/or office software. There will be no changes to the WSRN related to measurement units. The WSRN operates with geographical references, constrained to the National Spatial Reference System of the National Geodetic Survey (i.e., NAD83-2011 Epoch 2010.00), and applies geographic values (i.e., Lat/Long) and an ellipsoid height in meters.

Users should consult their respective local jurisdictions and applicable state agencies for any requirements to work in international feet and consult vendors for any questions about how to apply this (if applicable) in their field and/or office software. Read more about the deprecation of the US Survey Foot here.

What are the WSRN plans for the upcoming national datum shift?

The National Geodetic Survey (NGS) is planning on a new reference framework, NATREF 2022 (but will likely be in early 2026). This is a significant shift, much like the change from NAD27 to NAD83, by as much as 4 feet in WA. The state has put wording in the RCW/WAC to reflect this change. As we did with the shift from NAD83-CORS96 to NAD83-2011 (in 2012), our network and primary casters will be in NATREF, and we will provide an alternate caster in NAD83-2011 for a transition period of about a year.

Our plan to help users avoid using a datum they had not intended, is to make NATREF2022 available by a caster port named 2022, and for NAD83-2011 to be made available via a caster port named 2011. That way, a user will need to deliberately choose a respective datum. There will be plenty of prior notice ahead of the official datum shift day.

What kind of results should I expect using the WSRN?
Just like with a base-rover RTK setup or static, there are many factors and sources of error that can affect precision and accuracy: sky view, capabilities of the rover, age and quality of the rover and what constellations it supports, multipath, user errors, space weather conditions, and (to a much lesser degree) weather conditions.

In general, you should be able to get reliable and repeatable results under 3cm 3D with newer survey-grade gear. Note that there are many 'resource grade' receivers that are only designed to get sub-meter, sub-foot, or decimeter results; these are often work well, and are used for asset or resource mapping.

What field procedures should I use to gain confidence in my results?
This is a subject that would take volumes to cover and is much discussed among surveyors and mappers. Using the WSRN or any other RTN is not different from RTK fundamentals for base-rover (baseline length considerations we discussed earlier aside). All the WSRN operations team are surveyors, and we are keenly aware that surveyors must do whatever steps and analysis may be needed to have confidence in their data—confidence enough to stand behind their data. How each surveyor approaches this process is their call, based on their knowledge and experience. Therefore, we do not weigh in on what the "best" approach would be. Instead, we can relate some of the best practices our users have developed, and what we hear from peer RTN.

As with any use of GPS/GNSS, it is a rather mind-blowing proposition that using satellites 20,000km out can deliver what is needed to get centimeter results, as multiple sources of error can affect quality and repeatability. When taking a field 'shot', an amazing convergence of physics gets applied, and in short, a common best practice is to see if it can do that magic repeatedly under the same conditions and in slightly different conditions. To do this, multi-

observation methods are a best practice, doing things like reinitializing, and checking in on test marks, etc. There are tools in the many different field software packages that can help you do this in the field.

Some manufacturers accommodate multiple shots, on the same point, for a statistical analysis. Some users will reobserve at a different time of day, to affect a different satellite geometry (though there is less of a need for that with so many satellites up there now). There are even options in some field software to have it choose different geometries from the many satellites for you. Some may also offer an option for long observations, say minutes, and it does a kind of convergence, reducing outliers. Your vendor would be the best resource for what approaches might work best with your specific gear.

The Washington State Department of Natural Resources (WADNR) is in the process of updating its GPS guidelines document (2004). The new GNSS guidelines (available in 2026) will also include elements of new NGS guidelines (also being developed at this time). Once both are published, we will link them on the WSRN website.

Where can I find control points to check into?

A common method to test your field gear is to check results against published values on passive control marks. While there are caveats to doing this (more on this later), it is a practice that can be quite valuable.

There are many National Geodetic Survey horizontal and vertical control marks, and you can find datasheets for them through their interactive map and text lookup:
geodesy.noaa.gov/datasheets/

The Washington Department of Transportation maintains an extensive database of their control as well: wsdot.wa.gov/Monument/gis/index.html

Several cities and counties around the state maintain sets of control records. For example, the City of Seattle has an online database of vertical control. As does the City of Bellevue.

Keep in mind that when you are comparing an observed position to a published position, you must make sure you are comparing apples to apples. When using passive control, you need to consider the source, method of establishment, reference framework (datum), and especially the date. For example, there are control marks that may have multiple published values, and none of them are "wrong" per se. A mark might have an NGS value, a local county value, etc. They are all valid for the specific folks who published that value. However, you need to consider what datum and year the values were established. Due to plate tectonics, the value may have changed as much as 0.5' over 20 years. And there have been successive reference framework (datum) updates.

The WSRN constrains all stations to the National Geodetic Survey active control; the NGS CORS and our stations have been NGS 'Bluebooked' as published control marks. When you use the WSRN, you get a position in the NAD83-2011 Epoch 2010.00 reference framework, the same as if you did an NGS OPUS solution. Is the control record you are checking into expressed in the same reference framework as the current NSRS? Likely it has but look at the date of the record and consider how much plate movement has happened in the intervening years.

Establishing your own checkpoints can be very useful. Some firms and public entities set a point, for instance, in their parking lot. It comes in handy to see if all your gear is working before you head to the field. And to see if all the settings are OK and if you are getting the values in the reference framework you are expecting. There are several common ways folks establish coordinates on their own checkpoints. You could do several days of long static and submit it to NGS OPUS. Or do several hours of static and use the WSRN online post-processing tool for several hours. But also keep in mind that (depending on where you are in the state), the plate velocities can change values even after just a year (e.g., the coast).

Another idea for a checkpoint could be to establish one in public right of way, and Bluebooking it with the NGS. Once it is in the NGS database, they may publish new values when there are iterations of the national spatial reference framework. This could be handy as a check when there is a newly published datum (e.g. when the pending NATREF2022 supersedes NAD83-2011). Even if not Bluebooked, you can determine your own values for the new datum on your checkpoint.

What are the different zones on the printable map?

You should have received a PDF map of the WSRN with your login credentials email. You can get an updated map from the 'printable map' link in the lower left of the webpage. It is schematic, and not-to-scale. It indicates what stations are NGS CORS and which have been Bluebooked with the NGS. You will also see 6 zones or subnets. To effectively operate the WSRN, manage stations in areas of different velocities, and model factors like tropospheric scaling, we run 6 operational subnets with overlaps.

You will see designators like 'PRSN' for the Puget Sound subnet, PACWA for the coast, EWA for northeast WA, etc. There are respective VRS solutions for each subnet. The subnet is the prefix for VRS solutions in the mountpoint lists. For example, SEWAVRS_MSM is the SE region, VRS-type solution. And the suffix is the corrections format i.e., MSM is RTCM3.2-MSM; multiple constellations. See the Mountpoint Name Guide. Your crews must know how to change mountpoints, especially if they work in a different part of the state.
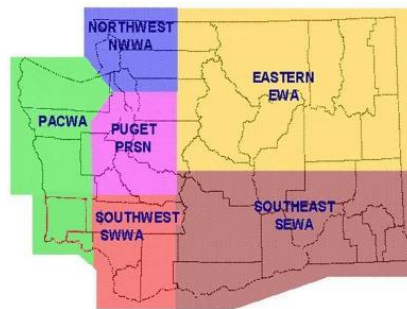
A generalized map of the subnets. For KML files of the subnets, download from
www.wsrn.org/CONTENT/Reference/WSRN_Subnets_KML.zip or
www.wsrn3.org/CONTENT/Reference/WSRN_Subnets_KML.zip

Are there some recommended presets for using the WSRN?

To take advantage of our redundant services, we recommend creating two of any preset: one for each caster. In some survey software, they call presets "survey styles". To avoid your crews getting stuck in the field, in the unlikely scenario that one of our servers/casters is down, having the presets means they can switch back and forth easily. We gave the two systems nicknames "108" and "121" (this is from the last 3 numbers in the respective caster IP addresses). We recommend 4 presets: one each for VRS for each caster, and one each for single base for each

caster. A naming convention for the presets adopted by a lot of our users is: "108_WSRN_VRS", "121_WRSN_VRS", 108_WSRN_SB", and "121_WSRN_SB".

How far outside of the network can I use it?

While the VRS corrections will work outside of the network, the rule of thumb for base rover RTK should be followed: no more than 10km beyond the outermost stations.

How much does the WSRN cost?

For partners that invest in WSRN infrastructure or host sites, there is no additional cost. For non-partners, there is an annual contribution, or "subscription". This is $1,900 per year for a single login. A bundle of 5 is $5,700, 10 is $10,000, 20 for $15,000, and combinations thereof. This is invoiced annually until the subscriber fills out a cancellation form.

Can I pay by the day, week, or month, and can I use a credit card?

The WSRN is only set up for yearly accounts. This is a relatively small operation, without the resources to manage complex accounting. Often for one-off projects, a test account works. Or, if a firm only uses it on rare occasions, we look at partnership opportunities that would reflect this. There is no mechanism for accepting credit cards (which would entail high fees). Never send a check until invoiced and only then to the accounts group specified. See the process below.

My invoice has late fees, how can we avoid this?

There are always unforeseen circumstances, like a change of contact email, company name, or billing address. Sometimes an invoice might sit on someone's desk, or in an inbox once sent, or gets sent to someone no longer there. Contact us if this happens and we can work on a resolution. But the best thing you can do to avoid this is please keep the WSRN apprised of any new billing contact name, email address, and mailing address (this is a requirement specified in any new agreements).

How do I apply for a subscription?

If you have not used a test account, we recommend you do so before formally applying for a paid account. To apply for a subscriber account, fill out, sign, and email us the combined 'Agreement and Application From'. The last page of the form is the application and is mainly just contact info. Be sure to provide a billing email and mailing address. Unless you want specific login names, we would prefer to assign those and/or simply use the same as you had with your test account (we have a preferred naming convention that helps streamline operations).

On the agreement, part of the form, leave the 'Anniversary Date' blank (we fill that out when signed at this end). Be sure to indicate the number of logins requested and initial next to that. Once signed at this end, an invoice will be sent after the next 15th of the month. Never send a check with your application, you do that once invoiced and only to the address specified on the invoice. A note about invoices: they look a little confusing, you will see odd amounts on different line items. This is an internal accounting thing, but they add up to your total for the subscription. You will be invoiced each year on the anniversary date.

How do WSRN partnerships work?

The infrastructure of the WSRN was funded and built primarily through partnerships: site hosts, contributions and loans of base receivers and antennas, power, communications, mount hardware, and software upgrades. To maintain, update, and improve the WSRN, new hardware and software are added continuously. Partners are given logins in exchange for the contribution or loan of hardware/software.

The needs of the WSRN change as we work through various upgrade phases, especially as the technology evolves and constellations modernize. For example, we may need antennas for a while, and new receivers at another time. Depending on the type/amount of hardware or software, a partner would receive 'x' number of logins for 'x' number of years. Contact us by email or phone if you'd like to hear about current partnership opportunities.

We're a school or scientific institution; how can we gain access?

Most public schools are eligible for academic accounts, as do most scientific entities. There are multiple federal and state agencies partnered with the WSRN, so contact us and we can look up if you are eligible under those partnerships for accounts.

We no longer need the WSRN, how can I suspend or cancel?

If you wish to suspend or cancel, please fill out, sign, and email us an 'Intent to Cancel Form'. If you have already received an annual invoice but then realize you'd like to cancel, we can check usage logs and cancel or prorate the invoiced amount accordingly. If you wish to sign up again in the future, we can reactivate with a new agreement.

Is the WSRN run by a state agency?

No, it is a public/private cooperative, with over 200 partners. Partners include cities, counties, utilities, academic and scientific institutions, and private firms. Individual Washington State Department of Transportation (WSDOT) regions are partners, hosting many of the reference station sites, as do other state agencies. One of the founding partners, Seattle Public Utilities (a department of the City of Seattle) operates the data center of the WSRN and manages the subscriptions. This cooperative model is a bit unique among real-time networks (RTN) in the U.S. and has been operating since 2001.

If the WSRN is run by the government, why isn't it free?

The WSRN is not a wholly government entity, it is a public/private cooperative, fully self-supporting. There is no direct state or federal funding, though we have applied for and received minor grants in the past. Subscription income is applied directly to operational costs; this together with partnerships, is for infrastructure construction, upgrades, and maintenance. Every dollar gets invested directly into the network.

Does the WSRN have an automated post-processing service?

Yes, we offer one, using the data from our stations (which includes some NGS CORS), which is nicknamed 'WAPUS'. This is similar to the NGS OPUS service and can be a good supplement for various field operations.

NOTE: Your files must be static, and between 5-minutes and 4-hours only. More than four hours would not provide any additional benefit, and large files slow down the processing queues. Be nice to your fellow users. We suggest 8-10 minutes, but if there are several stations nearby, you could do as short as 6 minutes. In sparse areas of eastern WA, do 10 min, but 30 if you have time.

NGS OPUS is an amazing public amenity that enables users to submit static files of 2 hours or more for post-processing, constrained to NGS CORS. There is also OPUS-RS, which can process observations for shorter periods. These can provide high-precision positions, with high confidence and fidelity to the national reference framework (datum). However, OPUS only works (presently) with the GPS constellation, though the multi-constellation M-Pagers Opus is in Beta. Still, many CORS are GPS-only; we are working with site operators in WA to seek to upgrade those CORS and add more.

The bigger challenge for using OPUS in WA: spacing and geometry. For example, there are no constraining CORS past the coast and few in Canada, and there are large holes in the middle of the state with no CORS. Users should look at the peak-to-peak values in the results; they may be higher than desired. Plus, the published positions for constraining NGS CORS may not be updated until they are as much as 5cm 3D out of tolerance (mainly due to plate tectonic velocities). We're seeking to densify the CORS in WA, but it is quite a process and the NGS is hesitant to add new CORS (we'll be persistent).

To provide our users with another option to post-process (e.g., when they work out of cell range or wish to check control values) we have an automated service that constrains to our stations, and NGS CORS (that are within tolerance). Registered users (e.g., partners and subscribers) can log in, choose 'Online Post Processing in the upper left of the page, submit static files from 6 minutes to 4 hours in length (please convert them to Rinex first) and our system does the baseline processing. It will return a PDF and/or an XML report of the results as NAD83-2011 geographic coordinates (not state plane; you will need to convert that yourself). Processing could take 5 minutes to an hour depending on the number of pending requests and the size of your uploaded file. You can see the progress by choosing "My Orders' and refresh or simply log in again later to see a list of your orders.

We recommend that new users of this service contact us so we can set up a live walk-through of the process.

Can I use the WSRN for my drone operations?

Certainly, though there can be a lot of nuance to this answer, as there are many different approaches that drone (UAS) operators take to meet their desired relative/absolute precision and accuracy goals. You can use the WSRN services, real-time and static, as part of such varied approaches—when appropriate.

For many drone operations, setting up a base on the site can be the best choice. Be that for real-time (RTK), or post-processing (baseline and PPK). This is because a very short baseline length can yield the best results. However, if your site is only a short distance from a WSRN station (e.g., under 10km on a good iono day), this could work well for RTK and/or static post-processing. Some users use VRS for their real-time data, and/or for establishing ground control points (GCP). Some users will use Virtual Rinex, requested for a virtual location on the site. Generally, working without GCP is not a preferred choice, unless you are only interested in relative precision, and even for that, including at least some GCP can be a best practice.

One aspect of processing drone data is the inertial (IMU) data, which when processed together with the observations from the on-board GNSS, in a PPK workflow, has grown in popularity. It is not as if PPK is much different than RTK (it is simply delayed RTK so to speak) but the addition of the IMU, and precise orbit data, that can make a difference. Your drone vendor can recommend software to do this PPK/IMU step. This is essentially the same as many mobile mapping workflows.

GLONASS considerations

The WSRN tracks and provides real-time (and static observation files) incorporating multiple navigation satellite constellation: GPS (Navstar), Galileo, Beidou, and QZSS (visible in coastal areas, though low to the horizon). Glonass is also incorporated. Glonass operates in a slightly different manner than the other constellations.

For example, Glonass is the only constellation to use Frequency Division Multiple Access (FDMA) instead of the standard Code Division Multiple Access (CDMA), as the satellite identity. Plus, there is a different time standard. These are esoteric differences and GNSS receivers mitigate for such differences quite well.

There is common question as to whether Glonass is a positive or negative addition to GNSS solutions. When Glonass was in its early phases (early 2000s) there were problems with reliability and noise. However, these challenges have mostly been overcome.

Using Glonass increases the number of satellites in view and can be a plus for satellite geometry (i.e., PDOP, VDOP, HDOP, etc.), especially in limited sky view situations. However, the constellation is widely viewed as still being a bit noisier than the other constellations. Some users consider this as a trade-off: more sats but possible a little more noise. Generally, most users will simply leave Glonass enabled. Most new rovers are very good at excluding non-optimal sats and signals from solutions.

On the newest rovers, that utilize most, if not all, sats and the 3rd. 4th, and 5th signals some broadcast. With this wealth of signals and constellation geometries, Glonass many not add anything (unless in a limited sky view situation) and some rovers simply use the other constellations first. Some older rovers are GPS, or GPS+Glonass only, and might need the extra sats Glonass provides for good geometry. You might want to experiment with your own rover.

General Geodesy, Surveying, and Technology Questions?

If a question is directly related to access to your account, and/or the status of, the WSRN, we are more than happy to answer emails and calls as rapidly as we can get to them. However, there have been many instances where folks get the impression that we offer more services and support than we are chartered to. Some misconceptions:

Is the WSRN the state geodetic entity? No, even though we do operate valuable geodetic infrastructure, constrained to the NGS reference framework. If there are matters of geodetic control, then you should contact the entity that established the control, like the NGS, WSDOT, cities counties, etc. For anything NGS related, contact your NGS regional advisor.

Does the WSRN publish surveying standards? No. Surveying standards (and recommendations) are published by federal, state, local, and private entities (e.g., ALTA), and professional associations/societies. There are updated GNSS guidelines currently in development by WADNR, and we will link those when published. The WSRN offers infrastructure and corrections and does not otherwise publish any procedures or standards.

<u>Does the WSRN support user hardware and software?</u> No. As explained in a prior section, there are too many combinations of make and model; your dealer or vendor is a better source for this type of support. Plus, we are prohibited from doing that: we cannot be doing the work that your service/support vendor should be doing.

<u>Is the WSRN a great 24/7 resource for anything tech-related?</u> No. Our operations may be pretty much on call during core business hours, but some folks will call at all hours. Note that in user/partner agreements our core hours for support are 9:00 am-3:00 pm M-F. While we try to be as helpful as we can and try to make the service work for everyone, sometimes folks take advantage of our availability—please do not do that. And please keep the questions to things related to the network.

Do not send your crews out there without any training on how to use the WSRN and expect us to do it. We have even had calls for help with setting up total stations, and even how to put gaming apps on phones (no kidding). We are not a 24/7 tech line; we are just part of a cooperative. With the help of all partners and users, we have been able to keep this amenity running for 20+ years, and with some of the best performance stats among RTN globally.

Some of the terminology in the FAQ is unfamiliar, can you explain that?

We aimed the FAQs at the core user groups, like surveyors, mappers, construction, etc. But there are new user segments, so if there are answers in the FAQ that you'd like further explanation on, contact us by email. Then we can set up a call or online meeting (or group training) to explain; we might be delayed but will get to those as soon as we can.

Do You Send out Regular Bulletins Via Email?

If you sign up for any WSRN services, the email you provided is added to the email list for when we send out update bulletins. Your contact info is shared with no one. We usually only send 2-3 bulletins per year, or if we are planning any major maintenance (though we typically do those after hours and users do not even notice).

If you receive a bulletin email and would like to stop receiving it, use the unsubscribe link in the bulletin. If you'd like to add a colleague to the email list, use the subscribe link in the bulletin.

Do You Send out Regular Bulletins Via Email?