

# National Weather Service



## SETTING UP A REMOTE WEATHER STATION

Updated 9/8/2011

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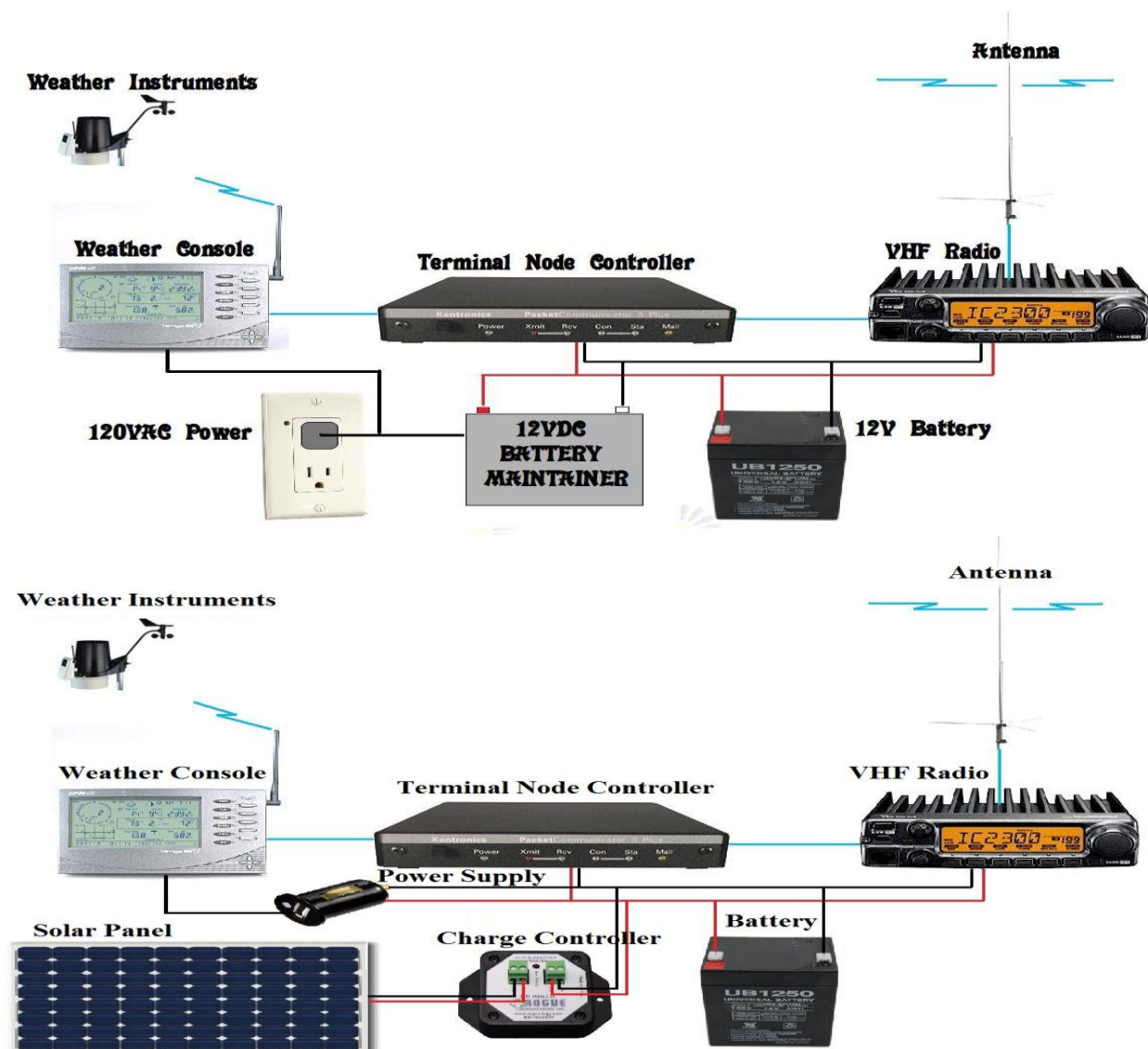
Hanford, CA 93230

559-584-9085

# Introduction

This guide will walk you through the setup process for installing a weather station using an amateur (ham) radio for reporting. Using an amateur radio requires a license which can be obtained from the FCC. We have included a parts list for setting up your weather station but these are only examples of parts that will work. The National Weather Service does not endorse specific brands or models. The parts listed were determined, through trial and error, to work for our particular requirements, yours may be different.

The stations we have set up at our weather office utilize an amateur radio form of digital communications known as APRS (Automatic Packet Reporting System). The national VHF frequency for APRS is 144.39MHz but may be different in some select areas. Here are two simplified block diagrams of all the required system components and their associated connections. The top diagram is an AC powered system while the bottom is solar powered.

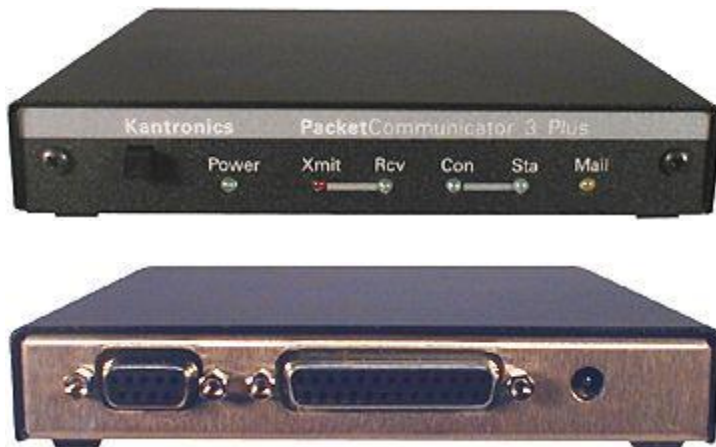


# Parts recommended for setup

**I-COM 2300h transceiver (\$250.00)** - This radio has many features that make it well suited for remote stations. Some of those features are; it doesn't have a cooling fan to fail, after a power failure it will automatically power up with all settings the same as before the failure, it has four power output settings, all settings are programmable from the face of the unit and it uses only 4 watts of power in receive mode.



**Kantronics KPC-3+ (\$200.00)** - This is the industry standard APRS TNC (Terminal Node Controller). Some of the features that make this TNC great for remote operations are; it can be remotely programmed once installed in the field, after a power failure it will automatically power up with all settings the same as before the failure, it requires no maintenance or rebooting and doesn't lock up. It has less than 1/2 watt power consumption.



**I-COM to TNC Cable KVIC45 (\$22.00)** - This cable will connect your TNC to your ICOM radio. One end has a DB-9 serial connection for the TNC and the other end connects to your radio with an RJ-45 plug to connect to your microphone jack and a 1/4" phono plug to connect to your audio out jack.



**Schumacher 1.5Amp Battery Maintainer (\$30.00)** - This battery charger / maintainer is great for remote



situation. Some of its features are; it provides a slow enough charge rate to not overheat batteries after power failure, it won't boil batteries by overcharging them, it requires no maintenance and it detects when the battery voltage drops and begins charging automatically. Make sure you choose one that provides 500mA-1500mA.

**Davis Vantage Pro II Wireless (\$400.00)** - This weather station works great for remote operations.



Some of the features it has are; APRS support from the manufacturer, solar powered station with battery backup, very low maintenance requirements, high degree of accuracy for measurements and can be calibrated for precision.

**Davis Weatherlink APRS edition (\$150.00)** - This software package includes three required pieces of

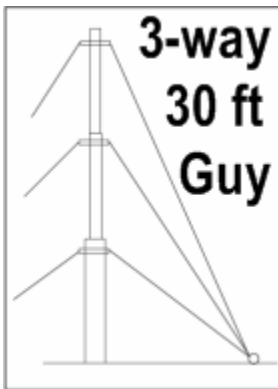


hardware to connect your Vantage Pro II. The data logger that plugs into the back of the console, the DB-25 adapter to plug into the TNC for connection to your Vantage Pro II Console and a DB-9 serial adapter for connection to a PC for programming and monitoring. It comes with software for programming your new data logger as well as software for directly monitoring the data on your console display.

**Comet GP-1 Antenna (\$175.00)** - The GP-1 Antenna provides excellent gain and weather resistance for exterior mounting. It comes with U-bolts for mounting to a mast. It is terminated with a female UHF connector on the base so you will need a cable terminated with double male UHF connectors if using this antenna.



**Rohn R-H30 Telescoping Mast (\$90)** – The Rohn telescoping mast provides all the support needed to hold a weather station. You can mount the anemometer at the proper 30 foot height and the other sensors at a lower working height. It will also hold the weight of other equipment such as a solar panel and APRS transmitter system. A big advantage is how easy it is to work on an anemometer or antenna at the top of the mast by simply dropping the sections down without needing to modify the guy wires.



# Theory of Operation

The Davis weather station reads the status of its weather sensors and transmits that information at 2.5 second intervals to the weather console via wireless 900MHz. The console then stores this information until the user defined interval is reached and it outputs this digital information to the T.N.C. (Terminal Node Controller). This interval is usually set to 5 minutes but may be set to any interval. Once the TNC receives this information it turns the digital information into audio for the radio to transmit. Once the TNC detects the frequency is clear to transmit, it signals the radio to begin transmitting and simultaneously sends the audio to the radio. The information is then either received by a repeater that will store your information and repeat it or it will be directly received by an I-Gate (Internet Gateway) that will then forward it to the national APRS servers. The NOAA MADIS computer will then ingest your weather information which will help provide more accurate forecasts for your area.

The power system in the example provided has a 12V battery powering the radio and T.N.C. while a battery maintainer keeps the battery topped off. This provides backup power in the event of a power failure or brownout. A typical 8Ah battery will provide approximately 8 hours of backup time. The weather console runs on AC power and has 3 C-cell alkaline batteries in the console capable of providing 9 months of backup power. In the event of a long duration power failure causing the 12V battery to fail, the radio and T.N.C. will power off causing a loss of communication. Once AC power is restored the maintainer will provide enough power to charge the batteries and run the electronics simultaneously. The radio and T.N.C. will automatically power up and begin transmitting weather observations.

An alternative power system for sites without AC power would be to remove the battery maintainer and install a solar panel in series with a charge controller. Some solar panels have the charge controller built into the panel. Davis also sells a solar option to power the weather console.

# Installation

When installing an APRS weather station the most important thing to do is check for APRS coverage at the site. There are three ways to check; ask your local HAM radio clubs, checking online web sites for other APRS stations in the area or by taking a transmitter to the site and checking online to see if your signals are getting out. Once you determine APRS



coverage exists at your site you will need to determine mounting options for your weather station. The Davis Vantage Pro II weather sensors need to be mounted within 300 yards of your console for proper reception (120 yards through walls). The instruction manual that comes with your weather station will have instructions for testing reception between your weather sensors and your console.

## Complete Vantage Pro II Kit

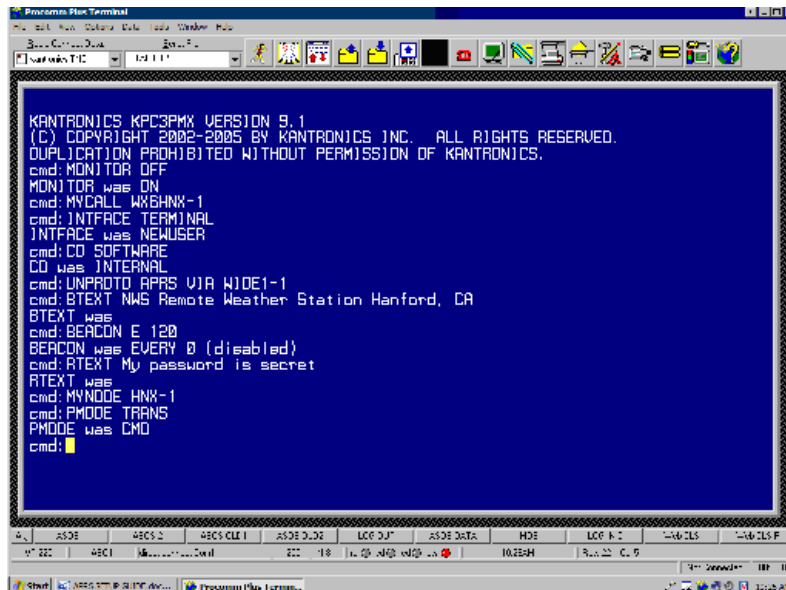


## Completed Project Box

In my example pictures I have enclosed the battery, TNC, radio and battery maintainer in a PVC junction box (12"x12"x6") which is available from home improvement stores for about \$35.00. This box is weatherproof and provides plenty of room. In the bottom of the box I have placed a duplex receptacle for plugging in the weather console and battery maintainer. I have connected the receptacle with a nine foot three prong pigtail cord. The cord, receptacle, handy box for the receptacle and receptacle cover costs about \$10.00 total. I have secured everything to the box by drilling small holes in the box and using 6/32 screws and nuts through the holes.

Once you have finished getting the hardware installed it will be time to power up everything and start programming the TNC. To do that you will need a computer with a DB-9 serial port, a serial cable with a DB-9 to DB-25 adapter. Once connected to the 25 pin port on the rear of the TNC load a program that can communicate through your serial port such as Procomm Plus or Hyper terminal. Be sure to set your configuration correctly, N-8-1 @ 1200 baud and VT-220 emulation. If connected correctly the TNC will display a firmware message once powered on. It will ask you to press the "\*" key and then will ask you to enter your call sign. I would recommend using your FCC given call sign with a dash and a number at the end.

For example if your call sign is WX6HNX you can use WX6HNX-1, WX6HNX-2... all the way to WX6HNX-15. This will allow you to use the same FCC call sign for up to 15 different stations. After entering your call sign the TNC will take you to the command prompt. Here is a list of commands that should be entered for proper operation.



```
KANTRONICS KPC3PMX VERSION 9.1
(C) COPYRIGHT 2002-2005 BY KANTRONICS INC. ALL RIGHTS RESERVED.
DUPLICATION PROHIBITED WITHOUT PERMISSION OF KANTRONICS.
cmd: MONITOR OFF
MONITOR was OFF
cmd: MYCALL WX6HNX-1
cmd: INTERFACE TERMINAL
INTERFACE was NEWUSER
cmd: CD SOFTWARE
CD was INTERNAL
cmd: UNPROTO APRS VIA WIDE1-1
cmd: BTEXT NWS Remote Weather Station Hanford, CA
BTEXT was
cmd: BEACON E 120
BEACON was EVERY 0 (disabled)
cmd: RTEXT My password is secret
RTEXT was
cmd: MYNODE HNX-1
cmd: PMODE TRANS
PMODE was CMD
cmd: █
```

## Procomm Plus TNC Programming

**MONITOR OFF** – This command tells the TNC to stop displaying APRS text received from other stations. You can turn **MONITOR ON** for troubleshooting purposes if you want to see other APRS transmitters in the area.

**MYCALL <YOUR CALLSIGN>** – The **MYCALL** command changes your call sign to whatever you want. Example “**MYCALL WX6HNX-1**”.

**INTERFACE TERMINAL** – This changes the TNC interface to terminal mode from new user mode. This will allow you to enter the more advanced commands to come.

**CD SOFTWARE** – This command tells the TNC to use internal software for carrier detection. Without this set to software it will rely on the radio’s squelch setting to tell it when someone else is transmitting. The TNC will not transmit if it detects someone else is transmitting.

**UNPROTO APRS VIA WIDE1-1** – This command lets the TNC know how you want your signal to go out. The **WIDE1-1** tells it to go out one hop. That means that a repeater seeing your transmission will repeat it but any station seeing the repeated signal will not be repeated again. Using the **WIDE1-1** will allow your signal to hit a repeater and go into an internet gateway that is line of sight to the repeater or it can go straight into an internet gateway if one is line of sight to your weather station. You can use as many hops as required to reach an internet gateway but avoid using too many hops so as to not flood far away areas with your weather data.



BTEXT <Insert station description here> - This should identify who you are, your location and the type of station you are. Example "BTEXT NWS Remote Weather Station Hanford, CA"

BEACON E 120 – This tells the TNC how often to transmit the text stored in the BTEXT. In this case it will transmit every 120 minutes.

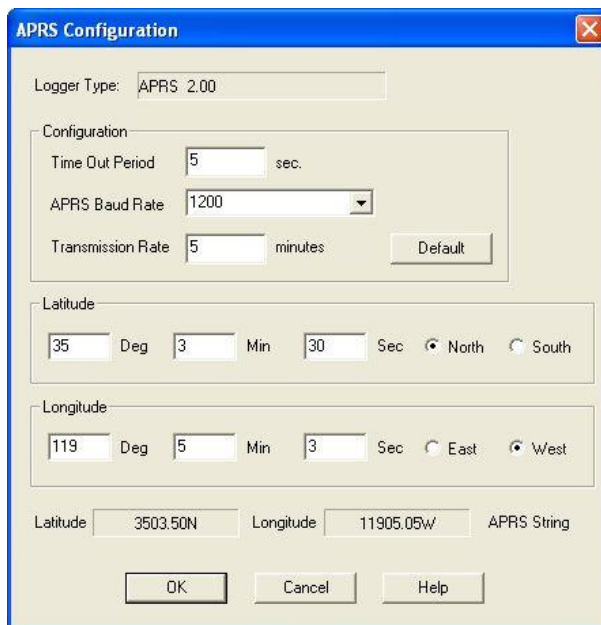
RTEXT <Insert Password String> - This is the password string that you will use to remote connect into the TNC in case you want to change settings remotely. Leave blank if you don't want to use that feature. This should be greater than eight characters.

MYNODE <Insert Node Here> - This also allows you to connect into the TNC remotely. You can set this to anything you want. For example if my station call sign is WX6HNX-1 I might set MYNODE to HNX-1.

PMODE TRANS – This tells the TNC to enter transparent mode after a power failure. With the TNC in transparent mode it will transmit anything it receives from the weather console. To exit transparent mode and return to a command prompt in the TNC hit CTRL-C three times.

NUMNODES 2 – This tells the TNC to allow up to two connections to the TNC at a time. This command is only necessary for remote logging in.

Now that the TNC is programmed you can disconnect the computer and power cycle the TNC. You will want to set the radio to 144.39MHz and adjust the power output to the correct level required. Pressing the DUP button on the radio will cycle through the different output levels. In some instances the low setting will be sufficient. Set the volume to a 25% level and the squelch all the way off.



When programming the weather console you will need to make sure to have the data logger that comes with the Weatherlink software installed. Then connect the DB-9 connector to the data logger phone cord and your serial port on your computer. Then load the "Streaming Data Utility" that comes on the Weatherlink CD. You will need to program the GPS position of the weather station, set the baud rate to 1200 and set the report time to 5 minutes. In most areas 5 minutes is the maximum report frequency. Now that the weather console is programmed you can disconnect the computer and connect your weather console to the 25 Pin jack on the TNC. You should be transmitting observations at this point.

## Streaming Data Utility

# Examples



The picture on the left shows an installed project box in Buttonwillow, CA. Since the antenna cable was fished in the wall to the attic it is not visible in the picture. The box was centered and screwed directly to a wall stud through the back of the enclosure. The picture on the right shows a completed project box with the cover off.



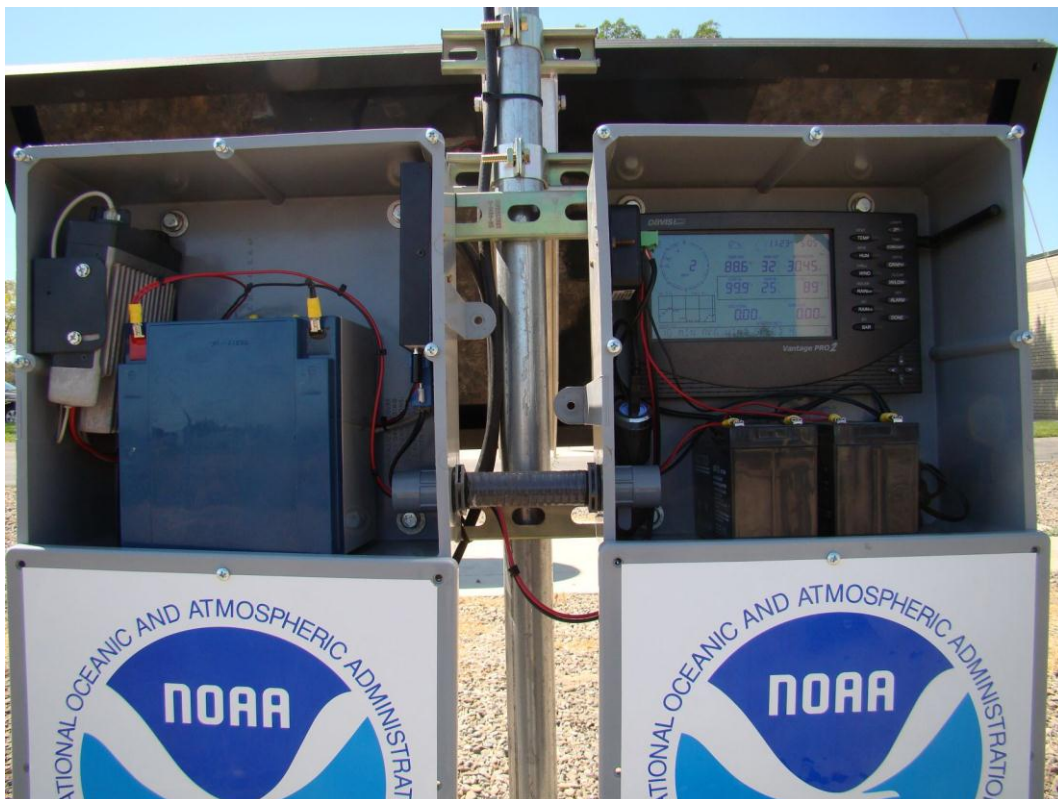
The above two pictures shows a solar install performed at Pacheco Pass. Instead of a standard console with display we used a weather Envoy in this setup. The pictures show two 7Ah batteries and one 26Ah battery with one 75 watt solar panel.



The above station is a solar station utilizing a full display console. It has 47Ah of batteries, 75W solar panel, and a 5A charge controller. Probably overkill but we were going for extreme reliability here. The bottom picture shows a similar setup with only 40Ah of battery capacity.

Here is a link to a video on how to build this solar powered APRS weather station below.

[http://www.youtube.com/watch?v=Fyn\\_IKp7s5A](http://www.youtube.com/watch?v=Fyn_IKp7s5A)



# Troubleshooting

The best way to troubleshoot the station if it is a remote station is by looking at the “raw” data. You can view the raw data your station is transmitting on sites like aprs.fi and findu.com. Here is an example of an APRS transmission.

```
WX6HNX-11>APRS,NCA1-1,qAR,NR6G-1:@221450z3636.25N/11843.98W_000/000g000t032r000p000P000h00b10041.DsVP
```

WX6HNX-11> -The originating station. In this case WX6HNX-11

APRS, -The type of transmission

NCA1-1, - The path to take. In this case Northern CA, with one hop

qAR, - How the packet was received. In this case directly.

NR6G-1: -The station that gated the information to the internet

@221450z - The day of the month followed by the UTC time of transmission

3636.25N/11843.98W\_ - The GPS location

000/000g000 - Wind direction (000-359) / wind speed / gust speed

t032 - Temperature in Fahrenheit. In this case it is 32 degrees.

r000 - Rain in the last hour in hundredths of an inch

p000 - Rain in the last 24 hours in hundredths of an inch

P000 - Rain since midnight in hundredths of an inch

h00 - Humidity in percent. Note 00 = 100%

b10041 - Barometric pressure in tenths of a millibar.

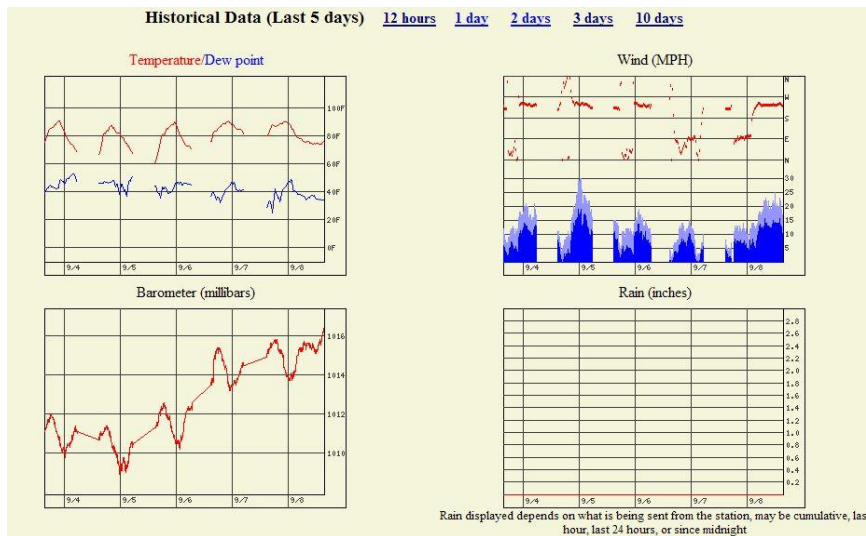
.DsVP - This is just a remark to indicate it is a Davis Vantage Pro

In this example you can see by looking at the raw data that the console is only intermittently receiving data from the ISS weather sensor transmitter. In this case the weather sensors were located too far from the console causing it to only sporadically receive weather data. A bad ISS battery may also cause similar problems. Note the pressure and precipitation history is always there because that is located inside the console.

```
WX6HNX-2>APRS,WIDE1-1,qAS,CDRVLY:@202343z3720.50N/11940.05W_000/000g000t040r004p099P080h87b10077.DsVP
WX6HNX-2>APRS,WIDE1-1,qAS,FSHCMP:@202348z3720.50N/11940.05W_000/000g000t040r004p097P080h..b10078.DsVP
WX6HNX-2>BEACON,WIDE1-1,qAS,CDRVLY:National Weather Service remote weather station Oakhurst, CA
WX6HNX-2>APRS,DEADWD*,qAS,K3UG:@202353z3720.50N/11940.05W_.../...g000t...r004p097P080h..b10077.DsVP
WX6HNX-2>APRS,WIDE1-1,qAS,CDRVLY:@202358z3720.50N/11940.05W_.../...g...t...r003p097P080h..b10077.DsVP
WX6HNX-2>APRS,WIDE1-1,qAS,CDRVLY:@210003z3720.50N/11940.05W_.../...g000t040r003p097P080h..b10078.DsVP
WX6HNX-2>APRS,WIDE1-1,qAS,CDRVLY:@210018z3720.50N/11940.05W_000/000g004t040r005p099P084h89b10078.DsVP
WX6HNX-2>BEACON,WIDE1-1,qAS,CDRVLY:National Weather Service remote weather station Oakhurst, CA
WX6HNX-2>APRS,WIDE1-1,qAS,CDRVLY:@210028z3720.50N/11940.05W_000/000g002t040r005p096P085h89b10078.DsVP
WX6HNX-2>APRS,WIDE1-1,qAS,CDRVLY:@210033z3720.50N/11940.05W_000/000g002t040r005p096P085h89b10079.DsVP
WX6HNX-2>APRS,WIDE1-1,qAS,CDRVLY:@210038z3720.50N/11940.05W_000/000g001t040r005p095P085h89b10079.DsVP
WX6HNX-2>APRS,WIDE1-1,qAS,CDRVLY:@210043z3720.50N/11940.05W_000/000g001t040r005p095P085h89b10079.DsVP
WX6HNX-2>BEACON,WIDE1-1,qAS,CDRVLY:National Weather Service remote weather station Oakhurst, CA
WX6HNX-2>APRS,WIDE1-1,qAS,CDRVLY:@210053z3720.50N/11940.05W_000/000g000t040r005p095P085h89b10082.DsVP
WX6HNX-2>APRS,WIDE1-1,qAS,CDRVLY:@210058z3720.50N/11940.05W_.../...g000t040r005p095P085h..b10081.DsVP
WX6HNX-2>APRS,WIDE1-1,qAS,CDRVLY:@210103z3720.50N/11940.05W_.../...g000t...r005p095P085h..b10082.DsVP
WX6HNX-2>APRS,DEADWD*,qAS,K3UG:@210108z3720.50N/11940.05W_.../...g...t...r001p095P085h..b10082.DsVP
WX6HNX-2>APRS,WIDE1-1,qAS,CDRVLY:@210113z3720.50N/11940.05W_.../...g...t...r001p095P085h..b10082.DsVP
WX6HNX-2>APRS,WIDE1-1,qAS,CDRVLY:@210118z3720.50N/11940.05W_.../...g...t...r001p095P085h..b10081.DsVP
WX6HNX-2>BEACON,WIDE1-1,qAS,CDRVLY:National Weather Service remote weather station Oakhurst, CA
WX6HNX-2>APRS,WIDE1-1,qAS,CDRVLY:@210123z3720.50N/11940.05W_.../...g...t...r000p095P085h..b10080.DsVP
WX6HNX-2>APRS,WIDE1-1,qAS,CDRVLY:@210128z3720.50N/11940.05W_.../...g...t...r000p095P085h..b10080.DsVP
WX6HNX-2>APRS,WIDE1-1,qAS,CDRVLY:@210138z3720.50N/11940.05W_000/000g001t040r001p096P086h90b10080.DsVP
WX6HNX-2>APRS,WIDE1-1,qAS,FSHCMP:@210143z3720.50N/11940.05W_000/000g000t040r001p096P086h90b10080.DsVP
```

Here is an example of a station that was intermittently transmitting a “-01” for wind direction. This is caused by a faulty anemometer directional encoder. If the console displays 360 for the wind direction, the APRS data logger will output -01. When the station transmitted the bad wind direction it caused the findU and CWOP servers to disregard the entire observation making it appear that weather observations weren’t being gated to the internet very often due to RF issues. But a close look at the raw data shows that the observations are being received and the problem was with the weather station. This is an engineering flaw with the APRS data logger.

```
WX6HNX-8>APRS,KELLER,WIDE1*,qAR,N6EX-3:@221815z3503.42N/11809.08W_000/000g004t048r006p089P057h94b10083.DsVP
WX6HNX-8>APRS,KELLER,WIDE1*,qAR,N6EX-3:@221820z3503.42N/11809.08W_000/000g002t048r005p089P057h93b10084.DsVP
WX6HNX-8>APRS,WA6LDQ-3,WIDE1*,qAR,KC6YRU:@221825z3503.42N/11809.08W_073/001g002t048r004p089P057h93b10085.DsVP
WX6HNX-8>APRS,KELLER,WIDE1*,qAR,AD6NH:@221830z3503.42N/11809.08W_073/002g003t048r004p089P057h93b10085.DsVP
WX6HNX-8>APRS,KA6PTJ-3*,qAR,K6MAR-10:@221835z3503.42N/11809.08W_073/002g005t048r003p089P057h93b10084.DsVP
WX6HNX-8>APRS,KF6RAL-15*,WIDE1*,qAS,KE6BB:@221840z3503.42N/11809.08W_-01/003g005t048r003p089P057h93b10083.DsVP
WX6HNX-8>APRS,KELLER,WIDE1*,qAR,N6EX-3:@221845z3503.42N/11809.08W_072/004g007t048r003p089P057h93b10082.DsVP
WX6HNX-8>BEACON,KA6PTJ-3*,qAR,K6MAR-10:National Weather Service remote weather station Mojave, CA
WX6HNX-8>APRS,KF6ILA-10*,WIDE1*,qAR,NG6B-4:@221850z3503.42N/11809.08W_074/004g007t048r002p089P057h94b10081.DsVP
WX6HNX-8>APRS,KELLER,WIDE1*,qAR,AD6NH:@221855z3503.42N/11809.08W_-01/009g010t048r002p089P057h93b10077.DsVP
WX6HNX-8>APRS,WIDE1-1*,qAR,W6MIN-15:@221908z3503.42N/11809.08W_-01/006g008t048r001p089P057h93b10076.DsVP
WX6HNX-8>APRS,KA6PTJ-3*,qAR,K6MAR-10:@221913z3503.42N/11809.08W_055/006g008t048r001p089P057h93b10075.DsVP
WX6HNX-8>APRS,KA6PTJ-3*,qAR,KC6YRU:@221918z3503.42N/11809.08W_-01/006g008t048r000p089P057h93b10075.DsVP
WX6HNX-8>APRS,KA6PTJ-3*,qAR,K6MAR-10:@221923z3503.42N/11809.08W_-01/004g008t049r000p089P057h93b10073.DsVP
WX6HNX-8>APRS,KF6RAL-15*,WIDE1*,qAS,KE6BB:@221928z3503.42N/11809.08W_060/004g008t049r000p089P057h93b10075.DsVP
WX6HNX-8>APRS,WIDE1-1*,qAR,W6MIN-15:@221938z3503.42N/11809.08W_-01/004g008t049r000p089P057h93b10073.DsVP
WX6HNX-8>APRS,KA6PTJ-3*,qAR,K6MAR-10:@221943z3503.42N/11809.08W_-01/004g007t049r000p089P057h93b10073.DsVP
WX6HNX-8>APRS,RODMAN,WIDE1*,qAR,W7RBV-1:@221948z3503.42N/11809.08W_-01/005g008t049r000p089P057h92b10071.DsVP
```



Here is an example of a Solar Powered station that had a faulty battery as viewed on findU.com. The transmissions were stopping every night and resuming in the morning. You will notice on the last day, the batteries were replaced and the system stayed up all night.

Q - After a power failure, my TNC lost all of its settings and I had to reprogram it.

A - You will need to replace the internal CR2032 lithium battery. This is a small disc battery that does not need soldering.

Q - I can't get to a command prompt on the TNC.

A - If you have programmed your TNC properly it should be in transparent mode. To exit this mode, simply press ctrl-c three times. After cycling power on the TNC it will automatically return to transparent mode.

Q - How many watts of solar power and amp hours of battery capacity do I need to operate a solar powered station?

A - The answer depends on many things such as location and transmission power settings. On the solar stations I've deployed, I used a 75 watt panel with 40 amp hour battery capacity transmitting on 5 watts with no problems.

# Information Links

Ambient Weather Davis Instruments products

<http://www.ambientweather.com/dainlowprqu.html>

Provantage Davis weather products

<http://www.provantage.com/davis-instruments-6540~7DAVS04X.htm>

Most current Wikipedia APRS information

[http://info.aprs.net/index.php/Main\\_Page](http://info.aprs.net/index.php/Main_Page)

Davis Instruments web site

<http://www.davisnet.com/index.asp>

APRS site for showing nearby repeaters and RF paths taken

<http://aprs.fi/>

APRS search page

<http://www.qsl.net/n9wtm/>

Kantronics official web site

<http://www.kantronics.com/>

FCC Amateur radio licensing

[http://wireless.fcc.gov/services/index.htm?job=service\\_home&id=amateur](http://wireless.fcc.gov/services/index.htm?job=service_home&id=amateur).

Davis Vantage Pro II APRS programming instructions

[http://www.davisnet.com/product\\_documents/weather/manuals/07395-218\\_Adendm\\_06540.pdf](http://www.davisnet.com/product_documents/weather/manuals/07395-218_Adendm_06540.pdf)