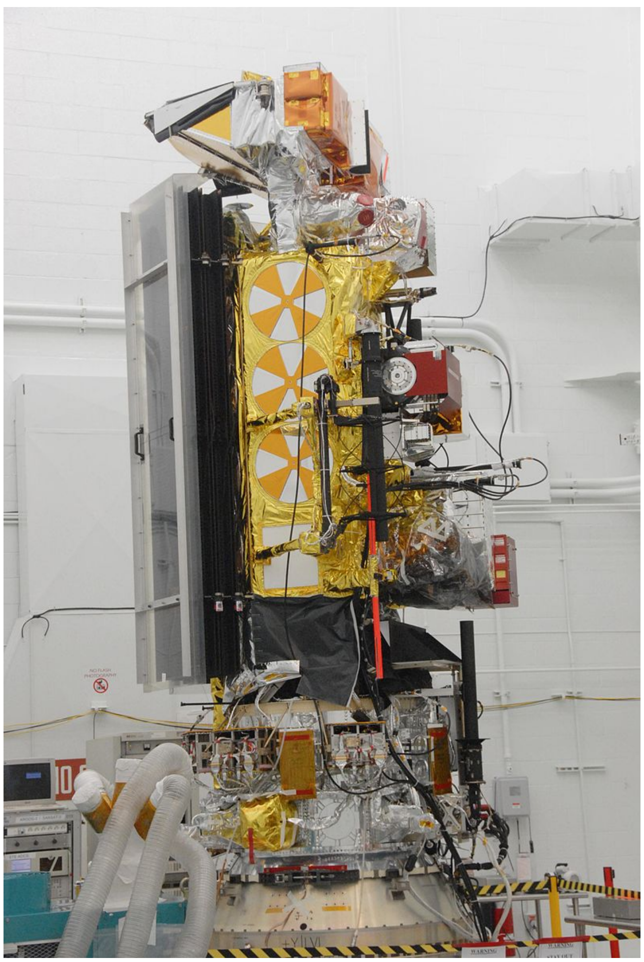
NOAA weather satellite notes

ShiftRegister

May 21, 2018



NOAA: National Oceanic and Atmospheric Administration
Gathering data to monitor and understand our dynamic planet

NOAA Satellites (NOAA-15, 18, and 19) transmit APT (Automatic Picture Transmission) signals as they fly overhead.

The recpetion and decoding of these signals can act as a foundation for listening to other satellites.

What is APT ?

The NOAA polar satellites series send continuous APT (Automatic Picture Transmission) signal and HRPT (high res multi channel) signal. HRPT reception requires a more complex system with a Yagi motorized tracking antenna on 1.6 Ghz range. The APT signal is analog and can be "heard" with a simple radio equipment on 137 - 138 MHz in FM mode. Notice that the bandwidth required is about 30-40kHz, which is not suitable with the Narrow FM standard (5-15kHz) or the Wide FM standard (~150kHz). The radio output audio signal is send to the computer sound card line-in and processed by the software. The audio signal contains a 2400 Hz sub carrier and has a special "signature".

The raw image consists of a visible channel + infrared channel, bordered with telemetry calibration datas. The infrared channel can be used for temperature reading and false color image computing. The temperature range is -60°C to +39°C.

Basically, APT is a sort of FAX image transmission. Pixel size is around 4 km in APT format. HRPT has a resolution of 1.1 km per pixel.

More information on the NOAA satellites we observe?

NOAA 15 (designated NOAA-K before launch) is one of the NASA-provided TIROS series of weather forecasting satellite run by NOAA. The satellite is placed in a sun-synchronous orbit, 807 km above the Earth, orbiting every 101 minutes. It hosts the AMSU-A and AMSU-B instruments, the AVHRR and High Resolution Infrared Radiation Sounder (HIRS/3) instruments, as well as a Space Environment Monitor (SEM/2). APT transmission frequency is 137.62 MHz. Due to problems with the S-band transmitter high-gain antennas, NOAA-15 has been configured for High Resolution Picture Transmission using the S-Band Transmitter #2 (1702.5 MHz) omnidirectional antenna.

NOAA 18, known before launch as NOAA-N, is a weather forecasting satellite run by NOAA. NOAA-N (18) was launched into a sun-synchronous orbit at an altitude of 854 km above the Earth, with an orbital period of 102 minutes. It hosts the AMSU-A, MHS, AVHRR, Space Environment Monitor SEM/2 instrument and High Resolution Infrared Radiation Sounder (HIRS) instruments, as well as the SBUV/2 ozone-monitoring instrument. NOAA 18 is the first NOAA POES satellite to use MHS in place of AMSU-B. APT transmission frequency is 137.9125 MHz (NOAA-18 changed frequencies with NOAA-19 on June 23, 2009).

NOAA 19 is the fifth in a series of five Polar-orbiting Operational Environmental Satellites (POES) with advanced microwave sounding instruments that provide imaging and sounding capabilities. Circling 530 statute miles [850 km] above Earth and completing a revolution every 100 minutes, the NOAA-N Prime will operate in the so-called "afternoon" polar orbit to replace NOAA-18 and its degraded instruments. The orbit crosses the equator from south to north at 2 p.m. on the trips around the planet. NOAA-N Prime is outfitted with instruments that provide imagery, atmospheric temperature and humidity profiles, and land and ocean surface temperature observations, all of which are key ingredients for weather forecasting. In addition, the information generates decades-long databases for climate monitoring and global change studies.

We will receive automatic picture transmissions (APT) from NOAA weather satellites using a cheap RTL-SDR (RTL2832U) software-defined-radio dongle and free software to track (gpredict), tune into and record (gqrx), convert (sox) and finally decode/image (wxtoimg, xwxtoimg) these transmissions.

NOAA APT transmissions are analogue transmissions. The data coming from the imaging sensors is used to amplitude modulate a 2.4 kHz sub-carrier, which is then used to FM modulate the VHF carrier at 137.x MHz. The FM deviation is 17 kHz and using the Carson bandwidth rule we get a channel bandwidth of

$\mathrm{BW} = 2 \times (17 + 2.4)$ kHz $= 38.8$ kHz

Hence the requirement for 40 kHz bandwidth. In fact, a few kHz more will not hurt but allow to track the signal during the whole pass without any active Doppler tuning.

which others could we listen to, or decode or otherwise observe?

EISCAT

EISCAT (European Incoherent Scatter Scientific Association) operates three incoherent scatter radar systems, at 224 MHz, 931 MHz in Northern Scandinavia and one at 500 MHz on Svalbard, used to study the interaction between the Sun and the Earth as revealed by disturbances in the ionosphere and magnetosphere.

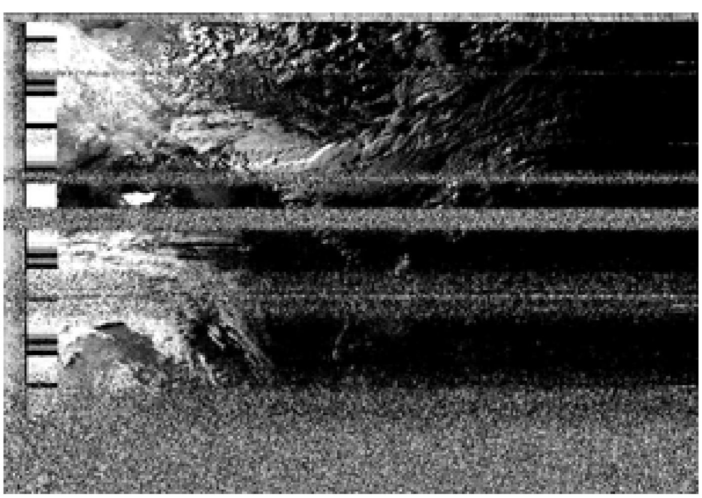
At Ramfjordmoen, near Tromsø, Norway the EISCAT facility has: a Ionospheric heater with HF radar capabilities; a tristatic VHF radar at 224 MHz with a 4 x 30m-by-40m parabolic cylinder antenna; and a monostatic UHF radar at 931 MHz with a 32 m parabolic dish antenna. From the start in 1981 the UHF radar was a steerable tristatic system, but due to interference from telecommunications in the 930 MHZ band, the remote receivers were converted to receive the VHF signal during 2012.

Others

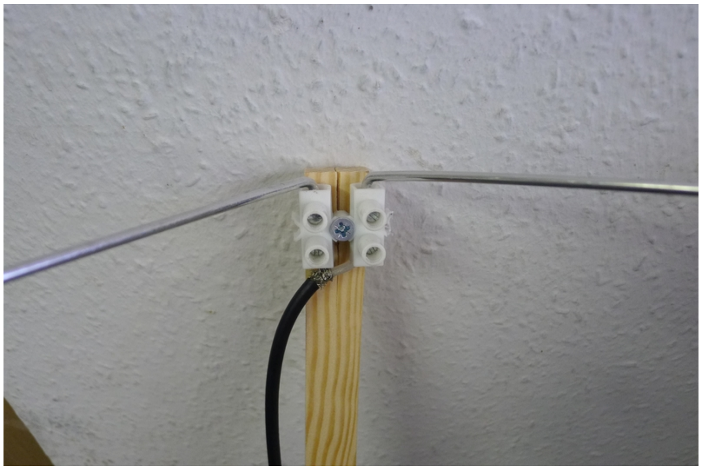
`https://www.rtl-sdr.com/receiving-dead-satellites-rtl-sdr/`

ISS: 145.825 MHz

HOWTO



Our antenna



A 120 degrees dipole of two 53.4 cm aluminium rods of 3mm thickness following:

`https://www.rtl-sdr.com/simple-noaameteor-weather-satellite-antenna-137-mhz-v-dipol`

Screwed into terminal block (53.4 is full length including end bend). RG-58 cable and crimped SMA plug.

We are using it pointing south.

A more fancy antenna (QFH) here:

`http://www.instructables.com/id/NOAA-Satellite-Signals-with-a-PVC-QFH-Antenna-and-/`

Tracking

gpredict works well

Set up:

Edit->Update TLE->from network

Edit->Preferences->Groundstations // to add where we are

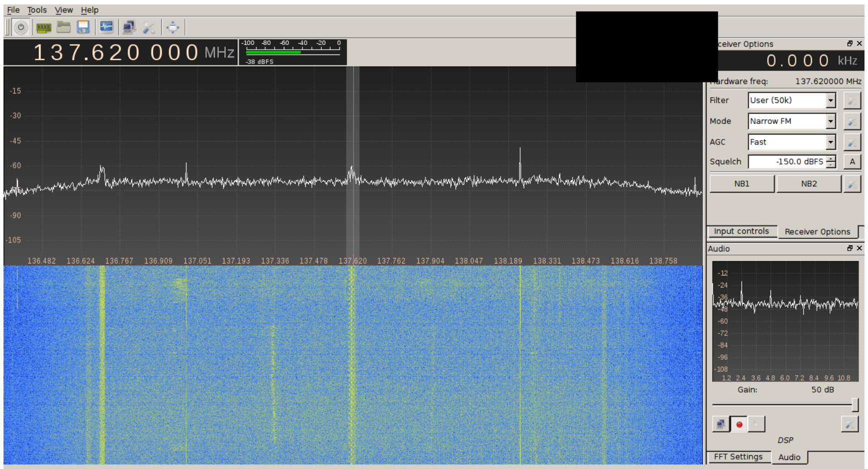
We look at NOAA 15, 18, 19: These are added in File->new Module

Tracking and images also on: `http://www.n2yo.com/?s=33591`

RTL dongles

RTL2832, 2560000 sample rate

Reception and post process - rtl_fm // gqrx



NOAA 15 => 137.620 MHz
NOAA 18 => 137.9125 MHz
NOAA 19 => 137.1 MHz
Refs:
`https://www.teske.net.br/lucas/2016/02/recording-noaa-apt-signals-with-gqrx-and-rtl`
`http://oz9aec.net/radios/gnu-radio/noaa-apt-reception-with-gqrx-and-rtlsdr`

```
pulseaudio -vvv
```

```
gqrx
```

Use narrow FM and 17k APT no tau in custom settings there
REMEMBER to always expand the filter by hand (click and drag) = user 50k
And set directory where it is recording audio.
Gain for rtl is full 50db.
DC REM / *IQ BALANCE* / NO AGC
Press record.
Afterwards process to 11025 samplerate with sox:

```
sox gqrx_20180428_155928_137912500.wav satnoaaQQ_1.wav rate 11025
```

wxtoimg

```
wxtoimg -a satnoaaQQ_1.wav satnoaaQQ_1.png
```

how to do mapping?

There are options in xwxtoimg

Image enhancements

IR imaging?
`http://oz9aec.net/radios/gnu-radio/noaa-apt-reception-with-gqrx-and-rtlsdr`

Older archived notes which might be helpful

why isn't it working?

antenna, receiver - to test?, receiver settings eg. less gain as in:
installing gqrx to test:

```
cmake .. -DLINUX_AUDIO_BACKEND=Gr-audio
```

to get rid of pulseaudio which was creating problems and hopefully now default to ALSA

but we had to install gr-osmosdr which might cause problems with rtl blah...

all a mess!

```
pulseaudio -vvv
```

seems to work with gqrx - tested with tiny antenna and 90.2 MHz WFM demodulation

which way is south?

Use the proper FM deviation (17 kHz) and filter width (45 kHz). Use proper gain setting for max SNR. With the latest rtl-sdr I had to use max gain setting. Use a sample rate that works well with your device on your computer (I used 1024 ksps).

Start by tuning the FCD PLL to 23 kHz above or below the satellite frequency. For example, NOAA-18 transmits on 137.9125 MHz and I tuned the FCD to 137.935 MHz. Then tune the channel filter so that the RX frequency will correspond to the satellite frequency

NOAA 15 => 137.620 MHz + 23k = 137.643 NOAA 18 => 137.9125 MHz NOAA 19 => 137.1 MHz + 23khz = 137.123

try: narrow FM and 17k APT no tau filter = user 50k

for NOAA 15 we have success - gain is full on - pointing south outside on the tables with basic dipole antenna...

we don't use the offset

older notes:

apt-get remove librtlsdr0

SDR hardware, what software? wx2img xwxtoimg: `http://www.wxtoimg.com/downloads/`

use of rtl-sdr or gprx?

`http://www.instructables.com/id/Raspberry-Pi-NOAA-Weather-Satellite-Receiver/`

but sox command doesn't work so use:

```
rtl_fm -f 137620000 -s 11025 -g 29 -p 22 - | sox -t raw -e signed -c 1 -b 16 -r 11025 -
```

aptdec doesn't compile at all:

`https://raspberrypi.stackexchange.com/questions/14433/record-audio-from-rtl-sdr-usi`

gprx we have problems with pulseaudio

alts:

fecha=$(date +%Y%m%d-%H%M)

timeout 900 rtl_fm -f 137.100M -s 48000 -g 44 -p 52 -F 9 -A fast -E DC NOAA19-$fecha.raw

To process:

```
sox -t raw -r 48000 -es -b16 -c1 -V1 NOAA19-$fecha.raw NOAA19-$fecha.wav rate 11025
```

Then to set the same date on the wav as on the raw:

touch -r /jffs/rtl/NOAA/NOAA19-$fecha.raw /jffs/rtl/NOAA/NOAA19-$fecha.wav

`http://kmkeen.com/rtl-demod-guide/`

`http://www.instructables.com/id/NOAA-Satellite-Signals-with-a-PVC-QFH-Antenna-and-/`

`http://www.instructables.com/id/NOAA-Satellite-Signals-with-a-PVC-QFH-Antenna-and-/`

```
/usr/local/bin/wxmap -T "${1}" -H $4 -p 0 -l 0 -o $PassStart ${3}-map.png
```

```
/usr/local/bin/wxtoimg -m ${3}-map.png -e ZA $3.wav $3.png
```

how to make QFH antenna: 3mm alu rods, block terminals as in pdf

see also: `http://www.alternet.us.com/?p=1461`

Making this live usb distribution

redo/installs

```
chroot chroot bash
```

```
rm live_boot/image/filesystem.squashfs
```

```
mksquashfs \
```

$HOME/live_boot/chroot \ $HOME/live_boot/image/filesystem.squashfs \ -noappend \ -e boot

```
mount /dev/sdb1 /mnt/usb
```

```
rsync -rv $HOME/live_boot/image/ /mnt/usb/live/
```

```
umount /mnt/usb
```

older syslinux version: `https://archive.is/8tjE8`
TODO: copy as backup to an image file with dd