Receiving NOAA weather Satellites Images using an RTL-SDR Dongle.

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The Automatic Picture Transmission (APT) system is an analogue image transmission system developed for use on weather satellites. It was introduced in the 1960's and over four decades has provided image data to relatively low-cost user stations at locations in most countries of the world. A user station anywhere in the world can receive local data at least twice a day from each satellite as it passes overhead. Their reception can be done using low cost DVB-T USB sticks containing the RTL820T or RTL820T2 chipset (figure 2) along with a QFH, Turnstile or Double Cross Antenna (figure 3), which can be homebrewed from PVC pipes, copper or coaxial cable.

As of July 2016, there are three NOAA APT satellites in service: NOAA 15, NOAA 18 and NOAA 19.

Essential Software
SDRSharp is a freeware Software Defined Radio interface which allows us to tune into the desired frequency. It is now distributed under the *Airspy* banner, and can be downloaded from their website at

http://airspy.com/download/

When you have downloaded *SDRSharp*, extract it into the folder where you wish to store it.

Orbitron is a satellite tracking system for radio amateur and observing purposes. It's also used by weather professionals, satellite communication users, astronomers, UFO hobbyist and even astrologers.

Orbitron shows the positions of satellites at any given moment (in real or simulated time). It's **free** (Cardware), and it's probably one of the easiest and most powerful satellite trackers. It can be downloaded from

http://www.stoff.pl/

WXtoImg is a fully automated APT and WEFAX weather satellite (wxsat) decoder. The software supports recording, decoding, editing, and viewing on all versions of Windows, Linux, and Mac OS X.
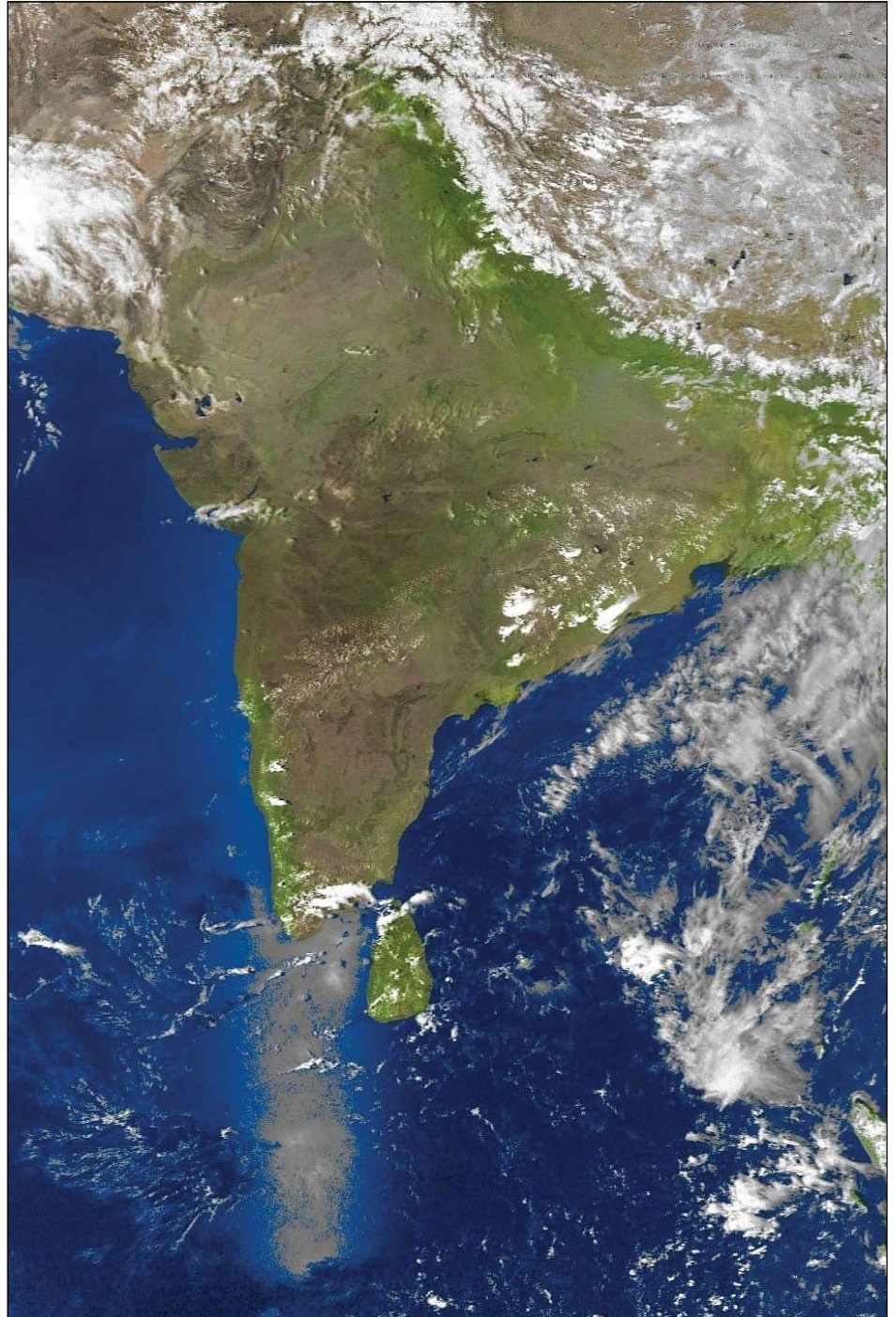
http://www.wxtoimg.com/

Figure 1 - This NOAA 19 image has been processed as MSA in WXtoImg

Figure 2 - A DVB-T dongle with RTL2832U, RTL820T or RTL820T2 chipset for reception.

Figure 3 – VU2MIB homebrew QFH antenna for NOAA reception

Figure 5a - The Windows Sound Manager recording tab

WXtoImg is now in the public domain (free) as explained in the previous issue [1] of *GEO Quarterly*.

VB-Cable (Virtual Audio Cable) is an audio driver that will port the audio from *SDRSharp* directly into *WXtoImg* for live decoding. You can download VB-Cable from

http://vb-audio.pagesperso-orange.fr/Cable/

After downloading and installing VB-Cable, open Windows Control Panel and double-click 'Sound'. The *Sound Manager* panel shown in figure 4 should appear.
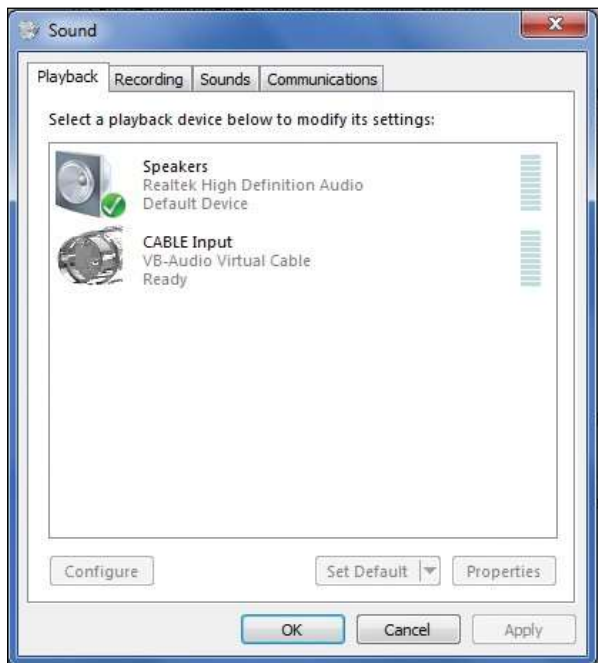

Figure 4 - The Windows Sound Manager playback tab

Set the default playback device as **Speaker**. This will allow you to mute the speaker while a satellite signal is recorded in the background using *Virtual Audio Cable*.

Set the default Recording device (figure 5) as **CABLE Output**. By setting VB-Cable as default recording device, *WXtoImg* will port the audio directly from the SDR's audio output.
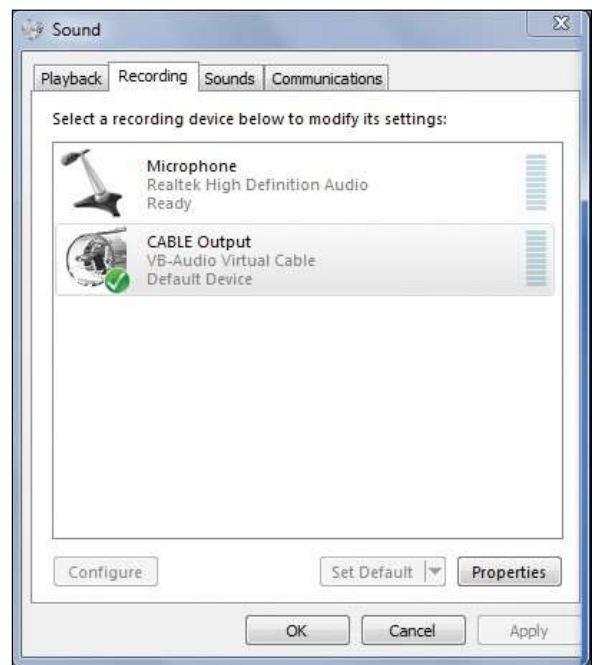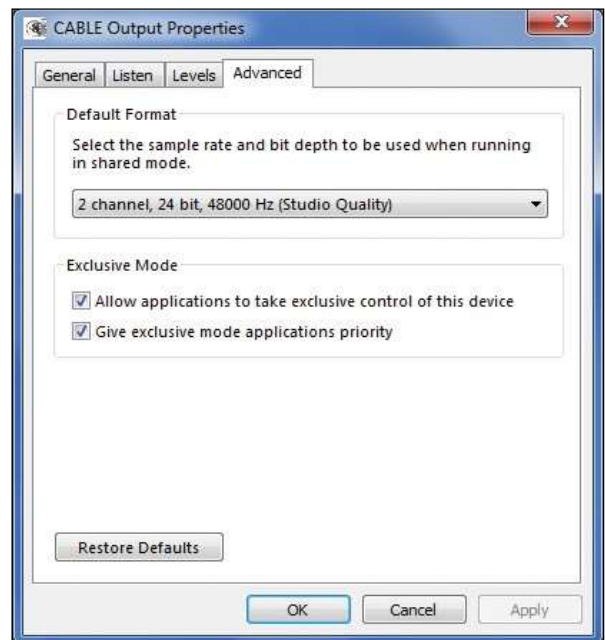

Figure 5b - The Windows Sound Manager advanced tab

Click the 'Properties' button on this screen to reveal the CABLE Output properties screen, and set the default format to 48000 Hz (Studio Quality).

Drivers for the RTL Dongle

Instal the RTL820T/RTL820T2 or RTL2832U drivers using the **Zadig** driver utility which is bundled with *SDRSharp*. To do this, you must first plug an RTL-SDR dongle into one of your computer's USB ports so that the **Bulk Interface** options become accessible. Now run **Zadig** as Administrator, to download and install the required driver. Make sure that the drop-down selector shows: '*BulkIn Interface (Interface 0)*'. If you can't see this option, click 'Options' and tick 'List all devices' first.

Installing the DDE Tracker Plugin

Download the DDE Tracker plugin from

http://rtl-sdr.ru/uploads/download/ddetracker.zip

This zip file contains three DLL files which you must copy into the *SDRSharp* folder. The zip file also contains a text file which contains the Magic Line, which you must copy and paste into the **Plugins.xml** file (which can be found in the *SDRSharp* folder).

Interfacing Orbitron with SDRSharp and DDE Tracker The most important task in configuring **Orbitron** to engage with both *SDRSharp* and the *DDE Tracker* module is to open the '*Orbitron/Config*' folder and edit its 'setup.cfg' file to add an entry for the *SDRSharp* driver. Load '*setup.cfg*' into a text editor such as *Wordpad/Notepad* and add the following two lines at the end of the file immediately following the [Satellites] section, then resave it.

    [Drivers]
    SDRSharp=C:\SDRSharp\SDRSharp.exe

Set the *SDRSharp* directory by replacing the default 'C:\' with the path to the SDRSharp folder.
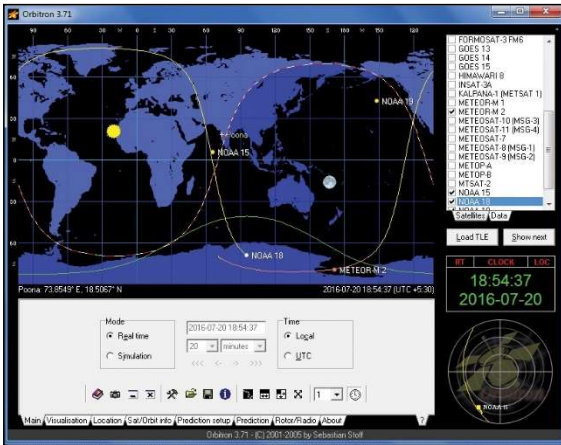
Configuring Orbitron

Figure 6 - Orbitron

Once the program is installed, start up *Orbitron* and click the Setup Icon

Open the '*TLE Updater*' tab and in the 'Group' field, select 'Weather'. Finally, in the right-hand panel, where you will find a list of satellite names, tick NOAA 15, NOAA 18 and NOAA 19.

Open the 'General' tab, and set your time zone.

Open the 'TLE Updater' tab and click on the farthest right icon to update the TLE files over the internet.

In the 'Miscellaneous' tab, set the AOS notification elevation at which you wish each satellite will give an audible alert as it approaches. It will also help to automatically trigger the satellite reception.
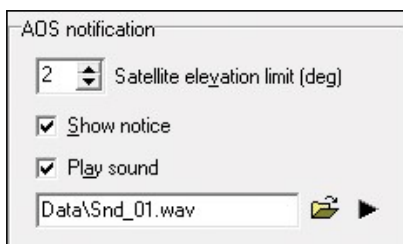

Figure 7 - Setting the AOS elevation alert

Finally, it is important to open the 'Extra' tab and select the final option 'AOS Notification: Make Satellite Active', then click 'Apply', as illustrated in figure 8.
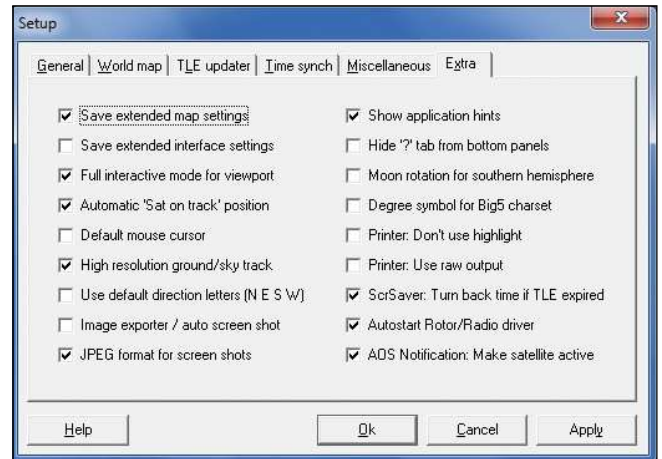

Figure 8 - Orbitron's *Setup/Extra* tab.

Set Satellite Frequency

Select the 'Rotor/Radio' tab at the foot of the Orbitron screen and enter each satellite frequency into the **Dnlink/ MHz** section This helps to cancel the Doppler Effect on the APT image. Make sure you have installed the DDE Tracker into *SDRSharp*, and Driver is set to 'SDRSharp'.

    Frequencies:
    NOAA 15 – 137.6200 MHz
    NOAA 18 – 137.9125 MHz
    NOAA 19 - 137.1000 MHz

Getting Started with SDRSharp

After installing the drivers for SDRSharp, start up *SDRSharp.exe*. In the top panel at upper left set the **Source** to RTL-SDR (USB) as we are going to receive the satellite signals via an RTL dongle connected to a USB port on the computer.
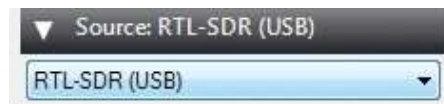

Figure 9 - Selecting the RTL-SDR USB driver

Open **Radio** and select Narrow FM (NFM), set the 'Bandwidth' to 32000, 'Order' to 10 (the minimum value for the audio filter), keep the 'Snap to Grid' option selected and select 'Correct IQ'.
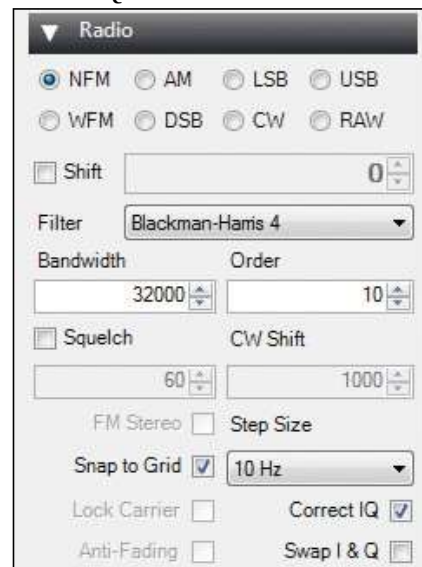

Figure 10 - The Radio Panel

Open the **Audio** panel, where it is required to set the 'Output' to CABLE Input (VB-Cable) – which will virtually pull the audio into the *WXtoImg* software.

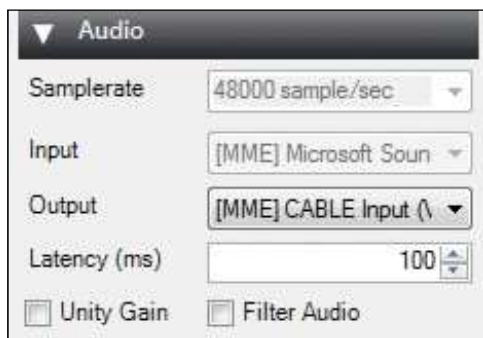Turn OFF both the 'Unity Gain' and 'Filter Audio' options.

Figure 11 - The Audio Panel

Open the **AGC** panel and make sure that the AGC is turned off (i.e. not ticked).

Figure 12 - The Automatic Gain Control Panel

Turn **off** the 'Audio Noise Reduction' and 'IF Noise Reduction'. If turned on the APT image might be smooth but loss of image quality and sharpness will occur.
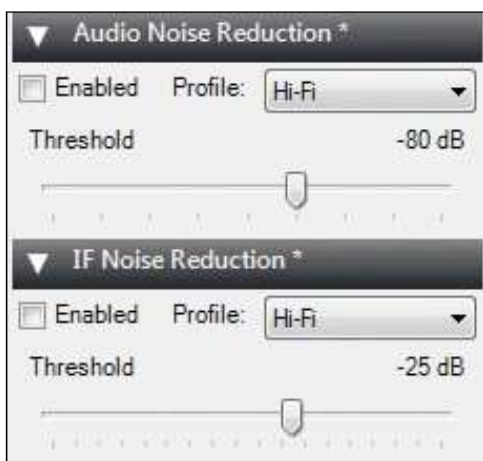

Figure 13 - The Noise Reduction Panel

Setting up the RTL SDR Controller

Settings for the RTL-SDR dongle are accessed by clicking the 'wheel' icon at top-left of the *SDRSharp* user interface. The Controller panel is illustrated in figure 14.

The **Sample Rate** can be selected from a number of set values, and I have found reception to work well using 1.8 MSPS, 1.4 MSPS and 0.900001 MSPS.

Adjust the **RF Gain** manually – usually you can set it up to 48 dB. If the reception of the signal is low try setting it up at 49.6 dB.
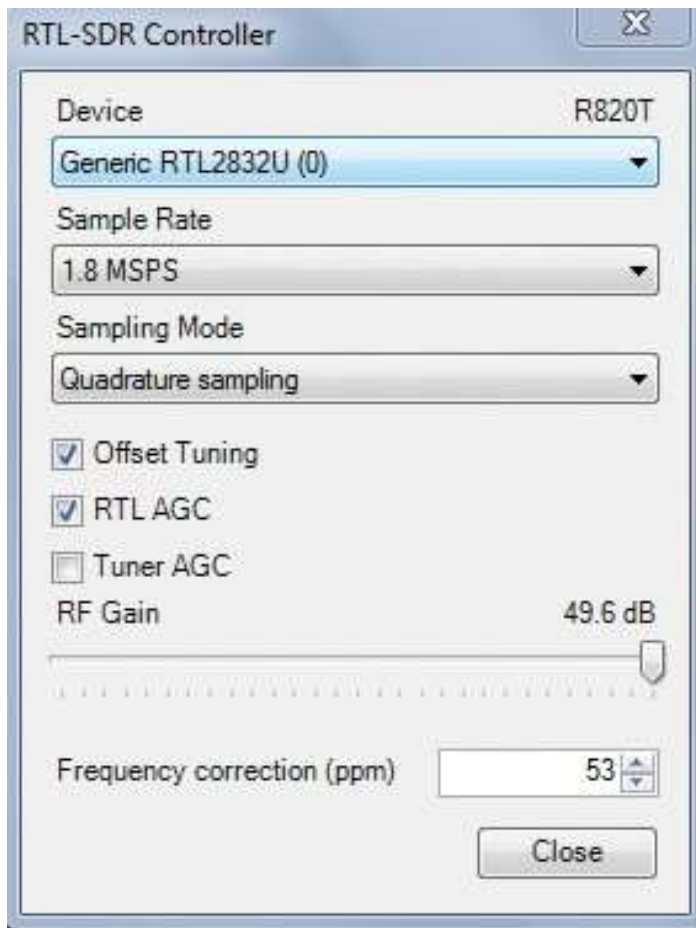

Figure 14 - The SDRSharp Controller Panel

Frequency correction (ppm) is required because RTL-SDR dongles are not precisely accurate. Because it is important that the satellite signal is precisely centred on the *SDRSharp* screen for optimum reception, this control can be used (usually under zoom) to fine tune the satellite reception peak to the centre of the display. Tutorials on frequency correction can be found online. In my case, I require frequency corrections between 53 and 76 ppm.

Configuring the DDE Scheduler

Now you have to enter appropriate commands into the **DDE Scheduler** (figure 16 - overleaf) in order to start and stop recording when a satellite is within range.

To open the scheduler, click the 'Config' button on the 'Tracking DDE Client' panel (figure 15).
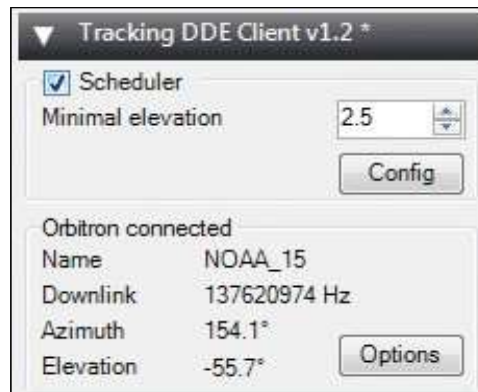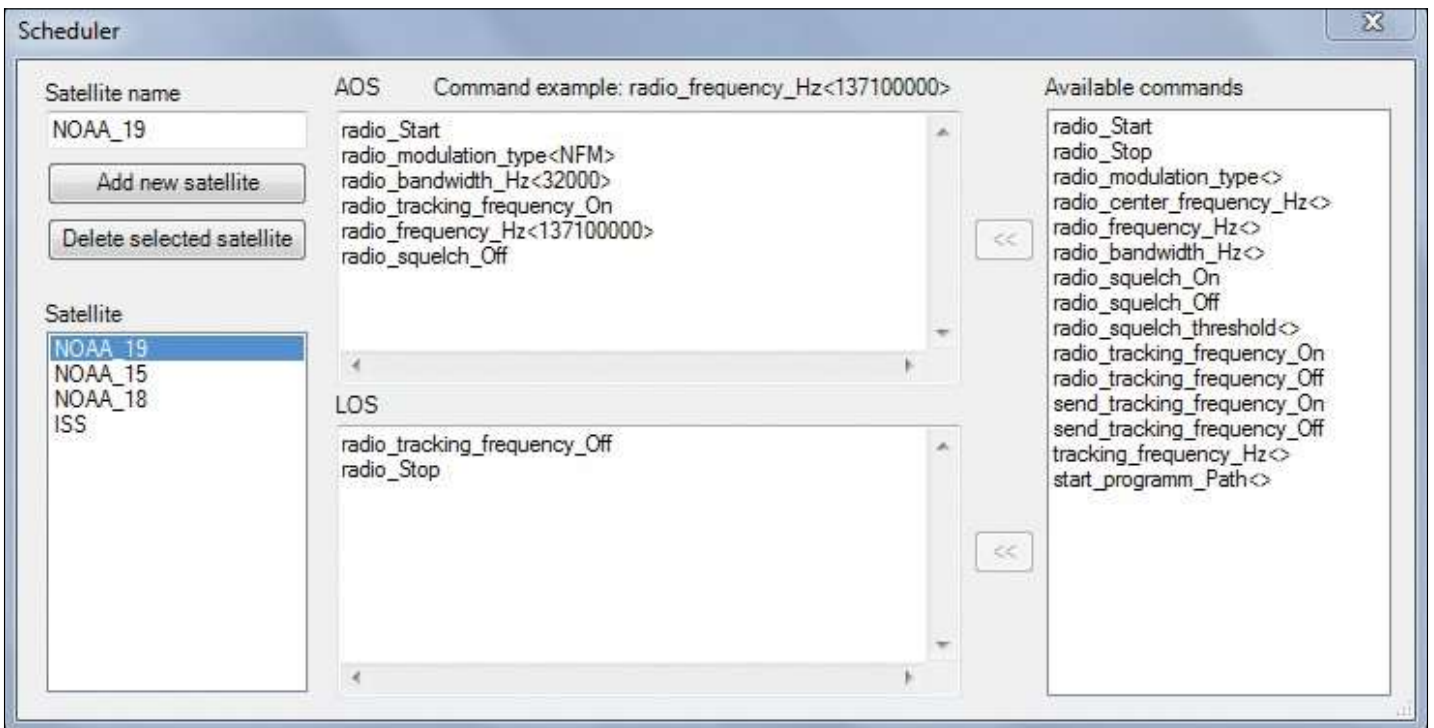

Figure 15 - The DDE Panel

Figure 16 - The DDE Scheduler

Enter The Satellite Name, Click on '*Add new Satellite*' and insert the commands as shown in above screenshot.

To enter a command, click to select it, then click the '<<' button beside the AOS or LOS panel as appropriate. The values between the angle brackets must be inserted manually by clicking between them then typing from the keyboard. Note that radio bandwidth and frequency <u>must</u> be entered as herz (not kiloherz or megaherz) as illustrated above for NOAA 19.

Setting up WXtoImg

If you have installed WXtoImg for the first time, you must start by setting up your Ground Station Location by going to **Options>Ground Station Location**. The city you are in should
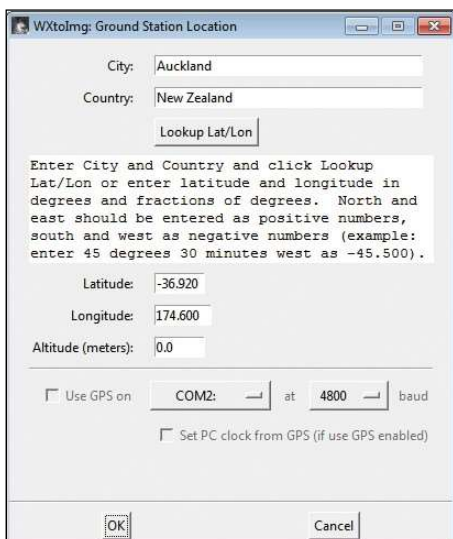
suffice, but you can be more accurate by entering an exact latitude and longitude if you want.

Next, go to **Options > Recording Options**, and ensure the correct device, *CABLE Output,* is selected under the soundcard option. Also, here, you can select '*Record only when active APT satellites are overhead*', and adjust the '*with maximum elevation above (degrees)*' and '*record only when satellite is above (degrees)*' settings (figure 19).

Finally, to enable automatic recording and image processing, go to **File> Record** to display the WXtoImg recording options screen (figure 20). If you click the '*Image Settings'* button, you can select the image types you want from a menu. Click the 'Auto Record' button, and WXtoimg will enter recording mode as soon as you run the program.
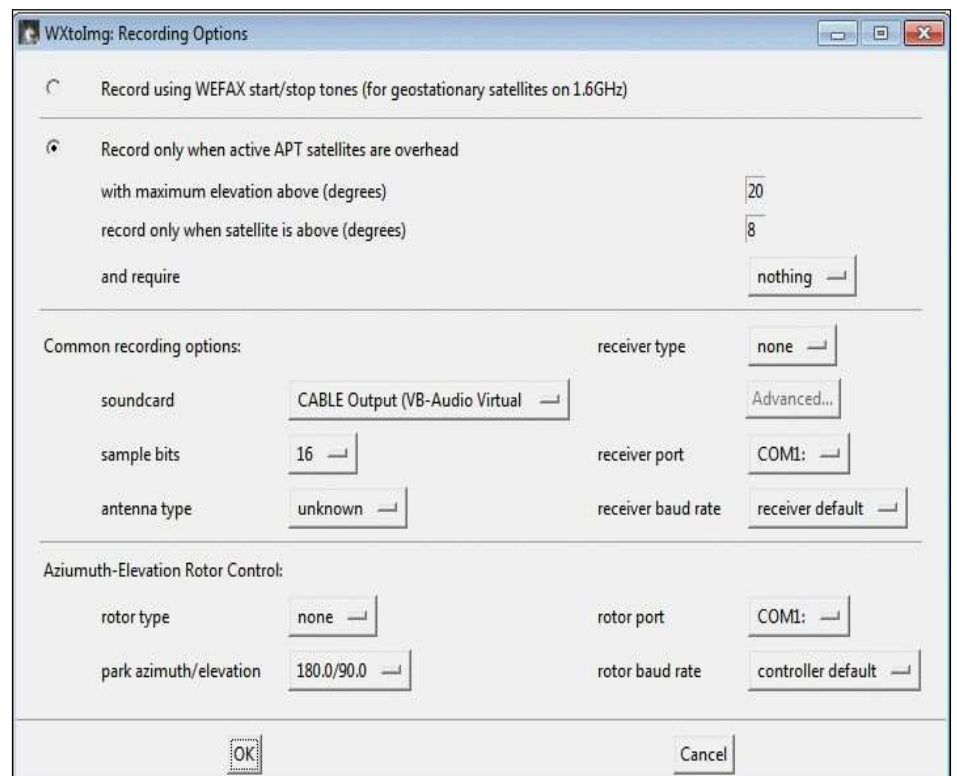

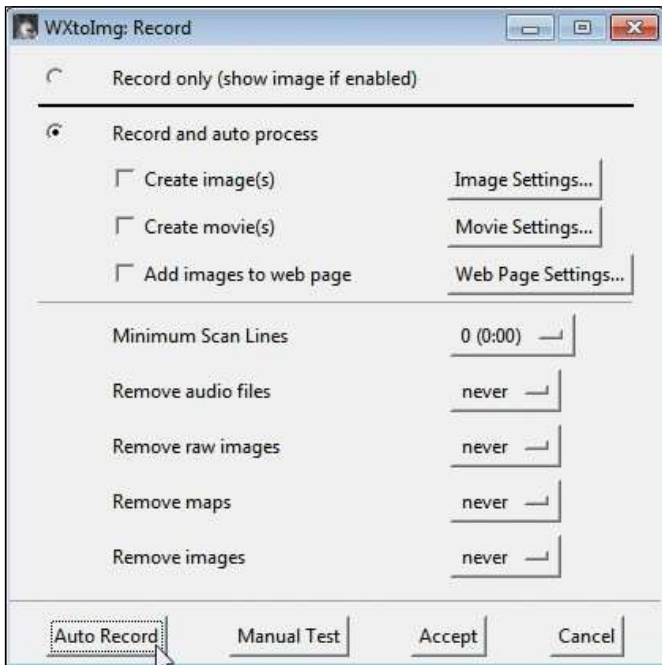Figure 18 - Setting Recording Options in WXtoImg

Figure 17 - Setting Station Details in WXtoImg

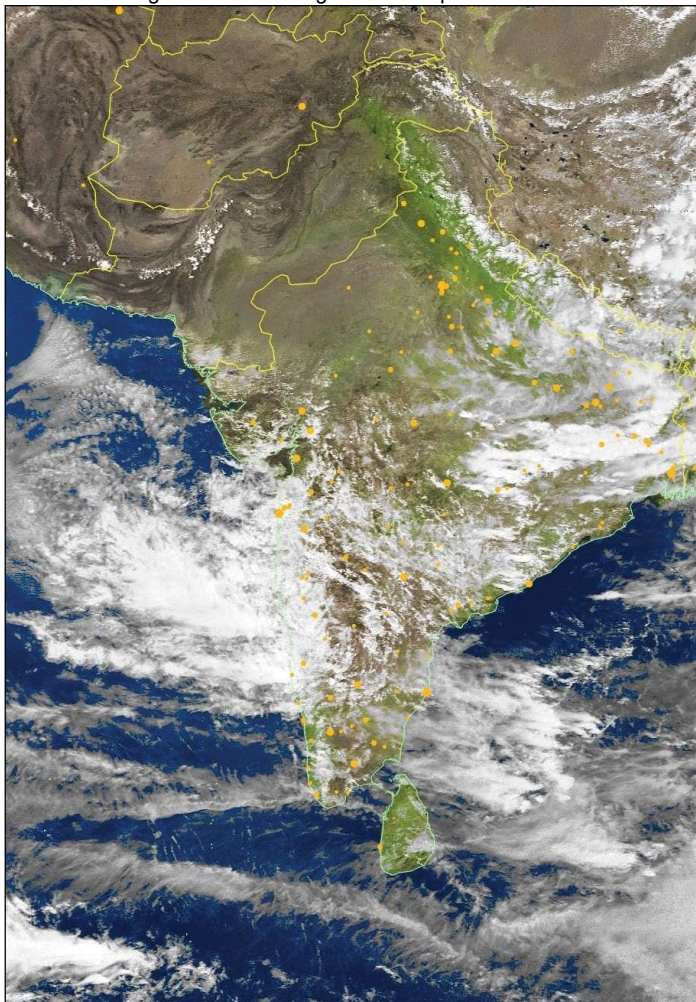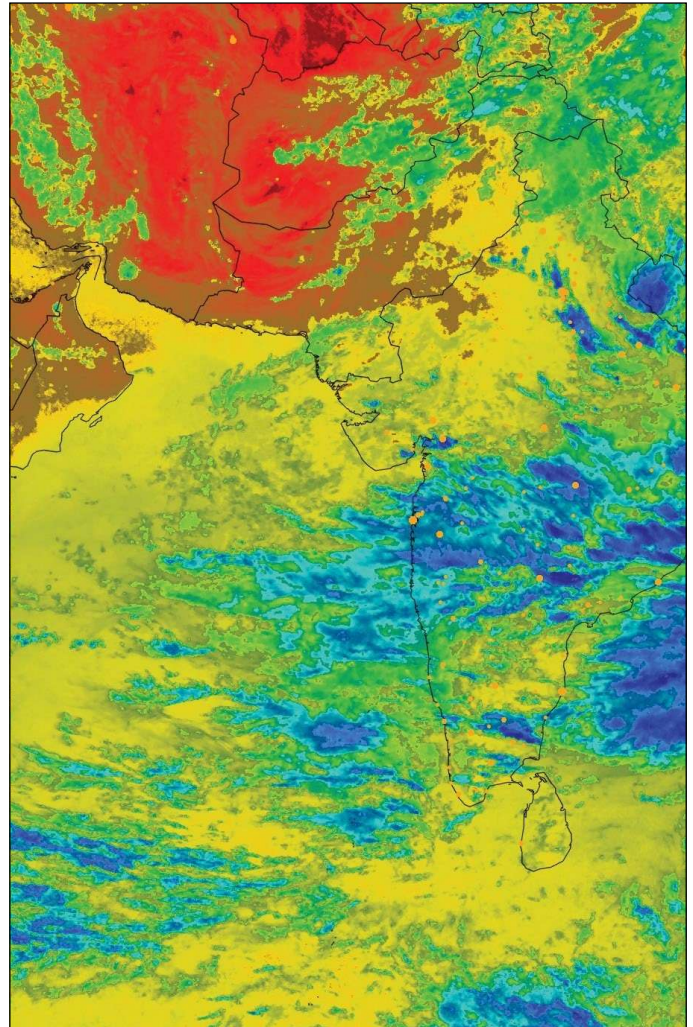Figure 19 - WXtoImg's Record Options Screen

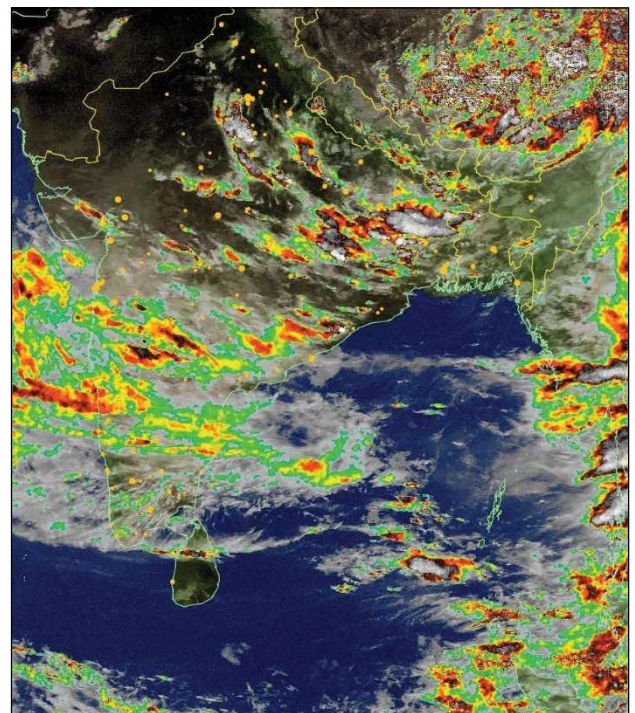Figure 20 - A WXtoImg MSA image

Figure 22 - A NOAA image processed using the
'MCIR with Precipitation' option

References

1 WxtoImg Upgrade Keys now Free - GEO Quarterly 50 (December 2015), page 43
2 Receiving Images from Meteor Satellites - GEO Quarterly No 48, page 27
3 User's Guide for Building and Operating Environmental Satellite Receiving Stations – NOAA
http://noaasis.noaa.gov/NOAASIS/pubs/Users_Guide-Building_Receive_Stations_March_2009.pdf
4 RTL-SDR Tutorial: Receiving NOAA Weather Satellite Images
http://www.rtl-sdr.com/rtl-sdr-tutorial-receiving-noaa-weather-satellite-images/