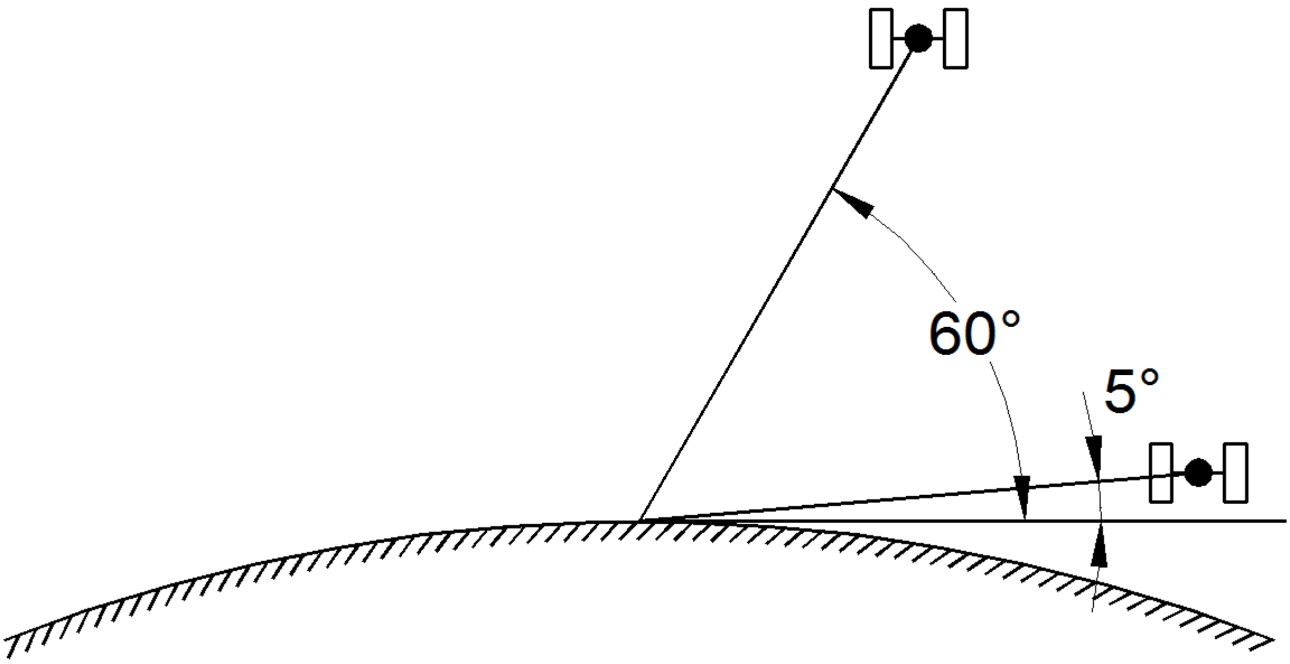
GPS And Glonass - Nigel Page - www.50k-or-bust.com

Soaring pilots are increasingly using complex navigation systems dependent on satellites for their operation. The GPS system of 32 satellites was the first system available but there are now other systems in place, principally the 24 Russian Glonass satellites. We already have GPS, so are Glonass satellites of value to us?

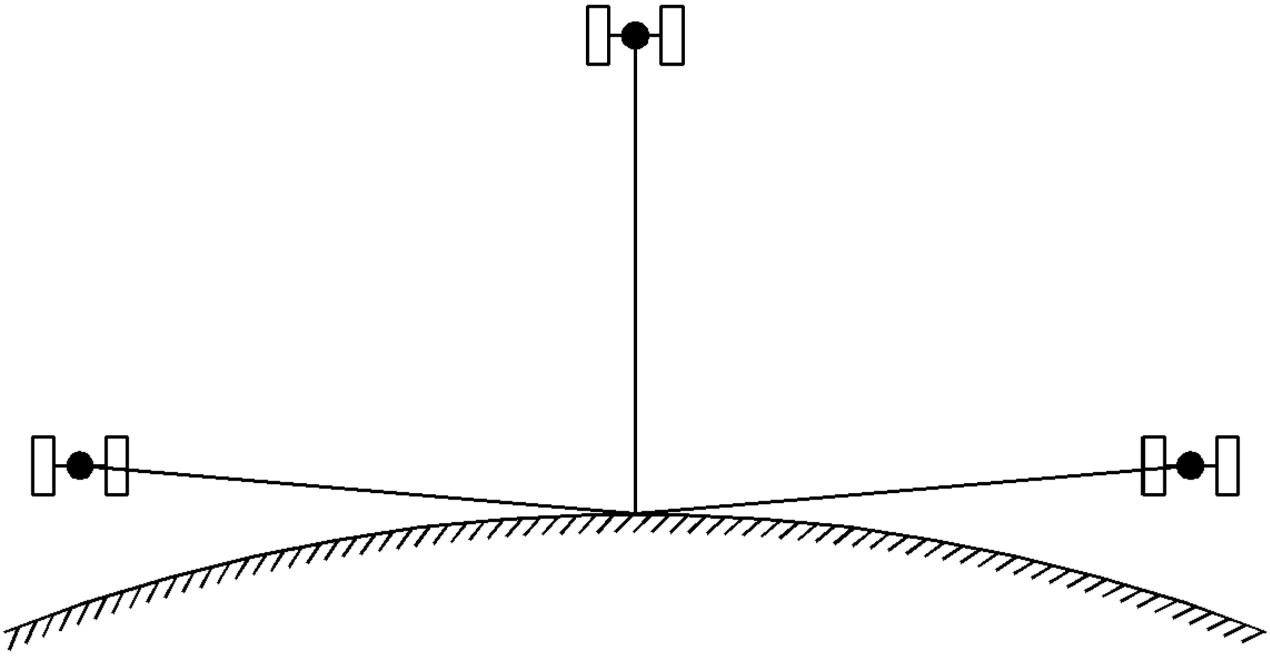
The orbit altitudes and transmission frequencies of GPS and Glonass satellites are similar and they suffer similar problems of reception. The science of the propagation of these signals is very complicated involving both terrestrial and space weather. However we can make some general observations about how the number and position of available satellites affect our systems. These diagrams are certainly not to scale and are only 2D representations of a 3D problem.

Firstly we have to understand what we mean by the “elevation” of a satellite.

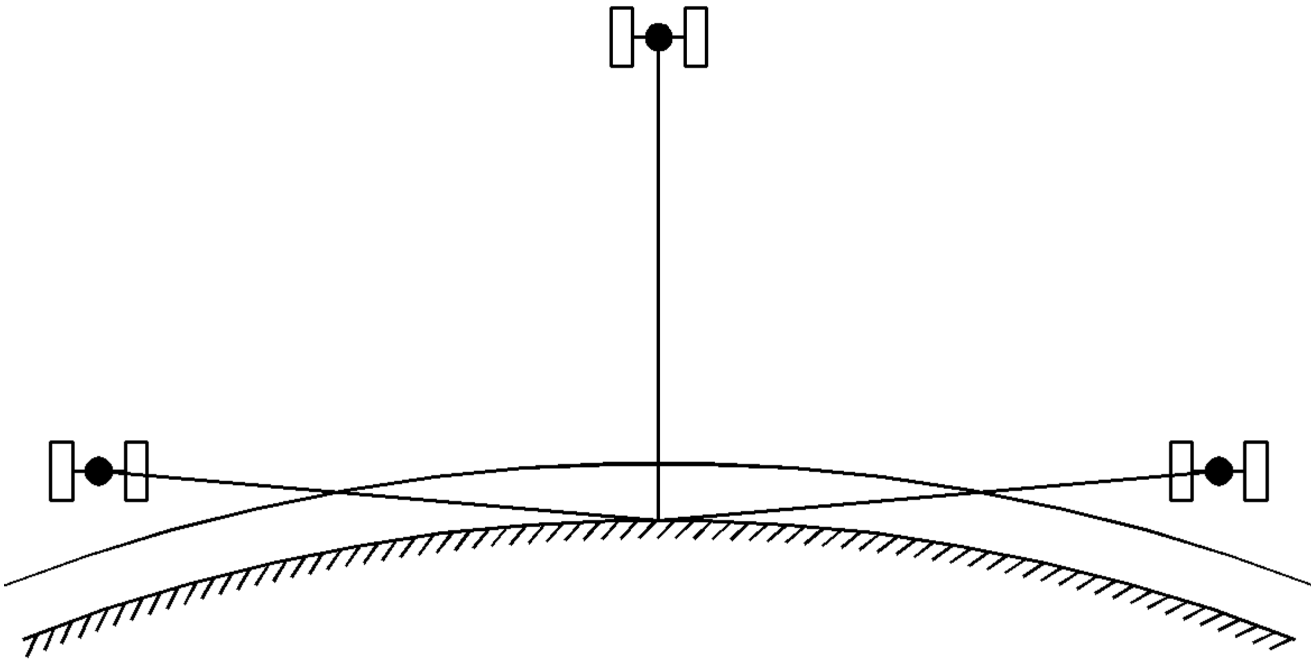


The elevation is the angle between the satellite and the horizon at the location at which we are receiving the satellite's signal.

Let's have a look at a situation with 3 satellites.

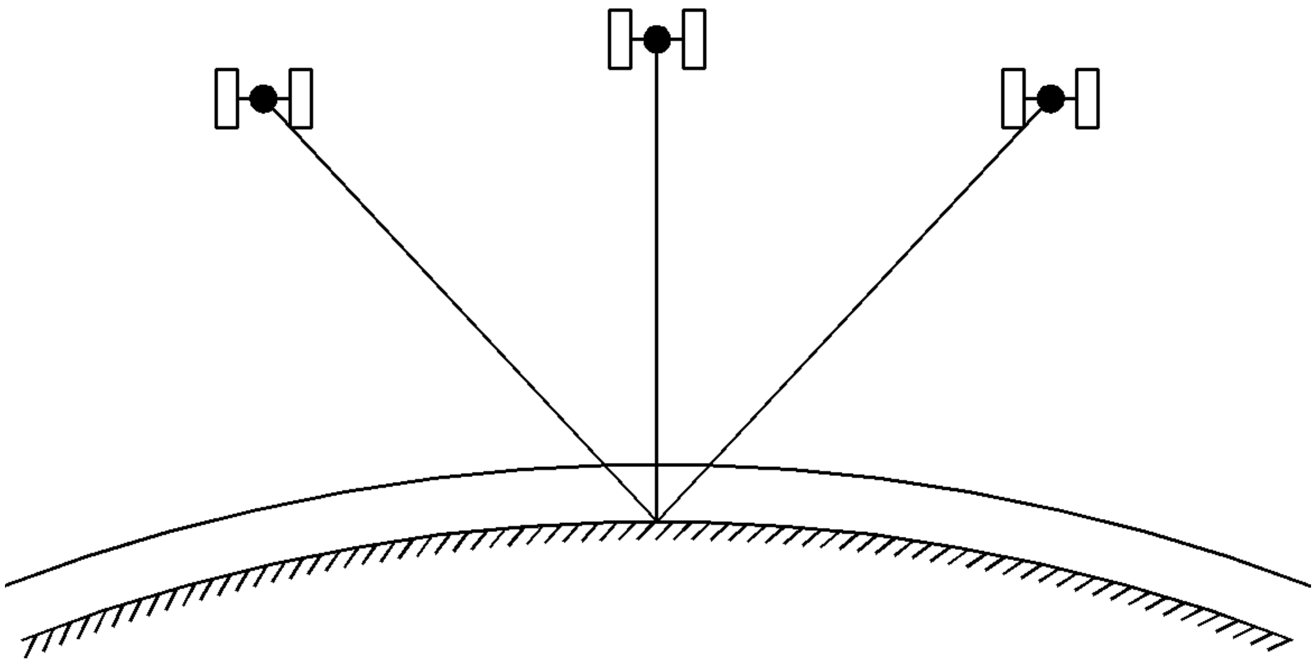


Here we have three satellites being received somewhere near the earth's surface. Compared to the altitude of the satellites (about 20,000 km) our altitude when soaring is very small indeed. Two of the satellites are at a low elevation and the third is at a very high elevation. Thinking in 2D only for the time being we might expect a good quality location from this scenario. The low satellites should give a good location horizontally and the high satellite should give us a good altitude measurement. Unfortunately it is not quite that simple.



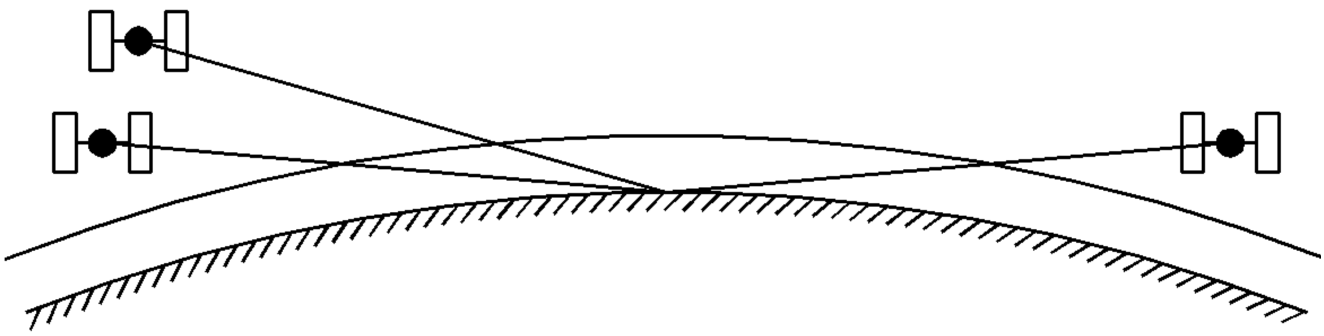
In reality the signals also have to pass through the atmosphere which distorts and weakens the signals. Signals from the the satellites of low elevation have to pass through much more of the atmosphere than the signal from the satellite at a high elevation. This degrades the accuracy of measurements using signals from the low elevation satellites more than those from high elevations.

Ideally we would like a nice spread of satellites at fairly high elevations.

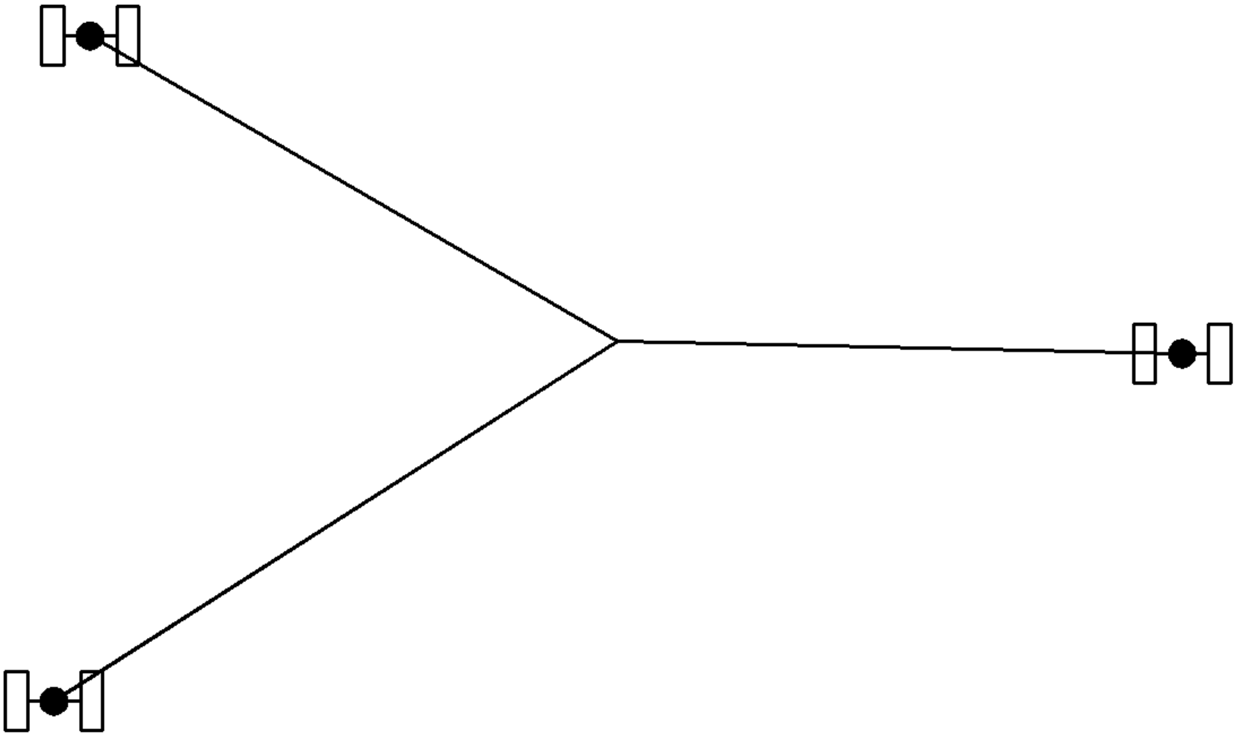


This gives fairly large angles between satellites and short signal paths through the atmosphere. We should have good horizontal location and altitude measurement.

If we only have satellites at low elevations things are not so good.



If this were a 3D situation we might have good horizontal angles between satellites for good horizontal location as seen in this view from directly above:

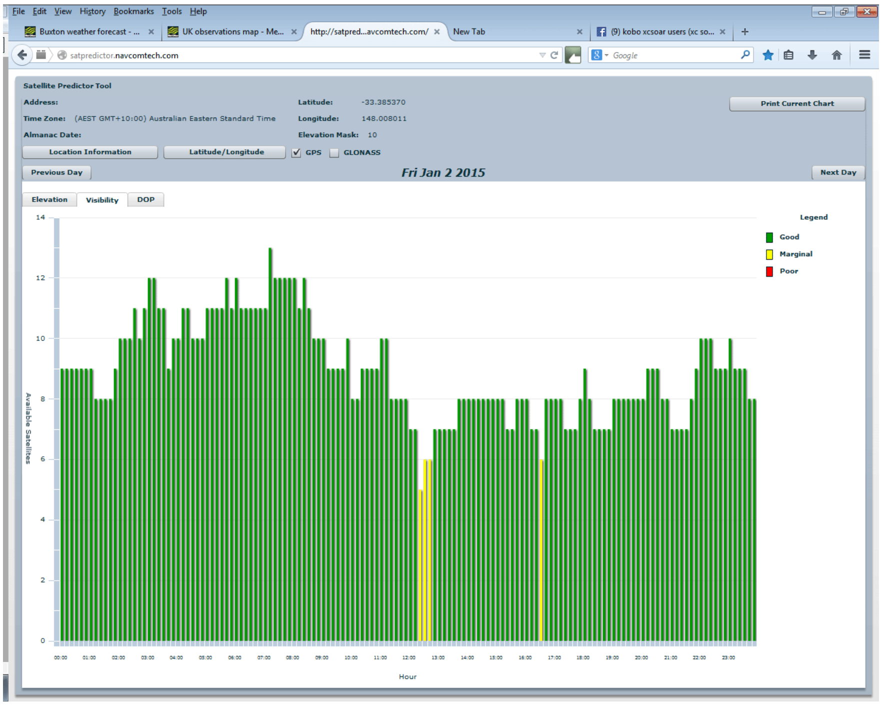


However all the signals have travelled through a lot of atmosphere so they will be weak and distorted. Perhaps this will be OK for general navigation but the accuracy of altitude measurement will be very poor indeed.

For a good 3D fix we want at least 3, preferably 4 good signals from satellites at elevations of, let's say, 30 degrees or more.

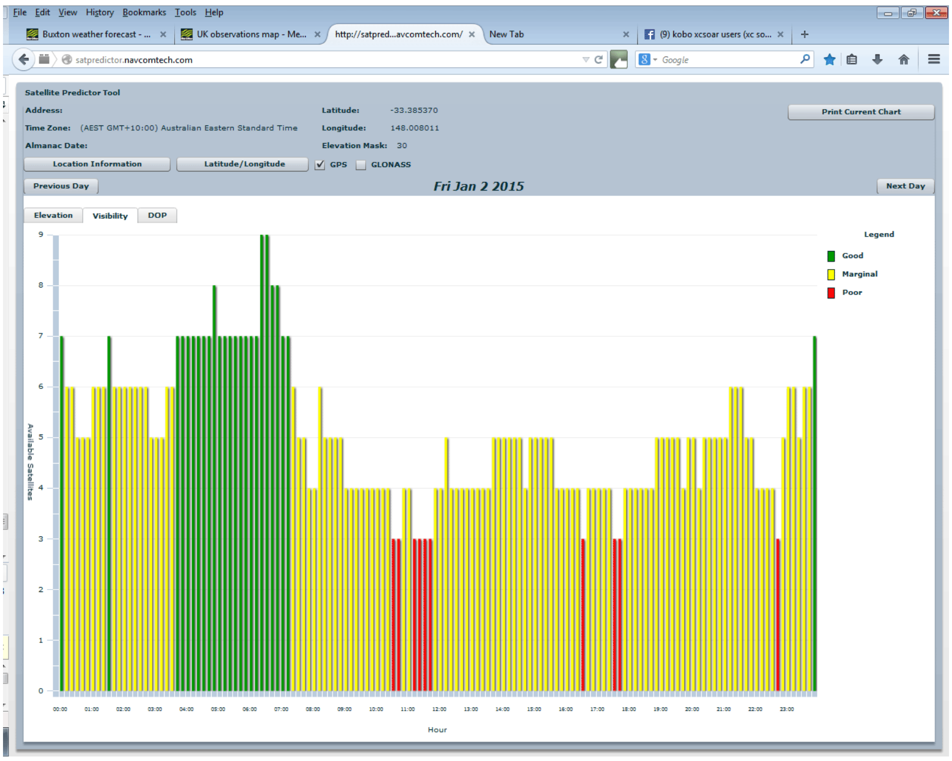
Examples of Poor GPS Signal Conditions

On the 2nd January 2015 several pilots at a hang-gliding competition in Forbes, Australia reported severe errors in GPS altitude readings. Let's have a look at the satellite cover at the time. The online “Satellite Predictor Tool” (http://satpredictor.navcomtech.com/) enables us to examine the “visibility” of satellites throughout the day at a particular place on a particular date. The following chart is for GPS satellites “visible” at Forbes on that day.



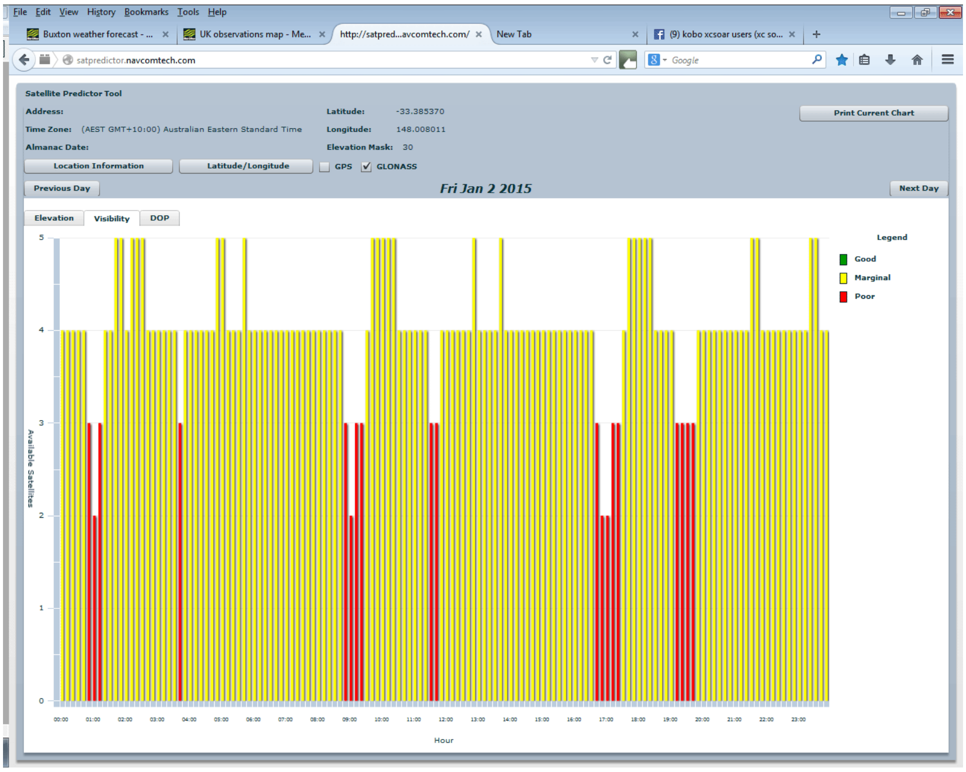
The reproduction of these charts is not good here but you can try this yourself online. The periods shaded green are described as "good" and the yellow (about 1230 and 1630) as "marginal" where 6 or 5 satellites are visible.

One of the settings on the predictor is "elevation mask". This masks off satellites whose elevation is below a selected angle and in the above chart it is set to 10 degrees. If we set this mask to 30 degrees we get a very different picture.

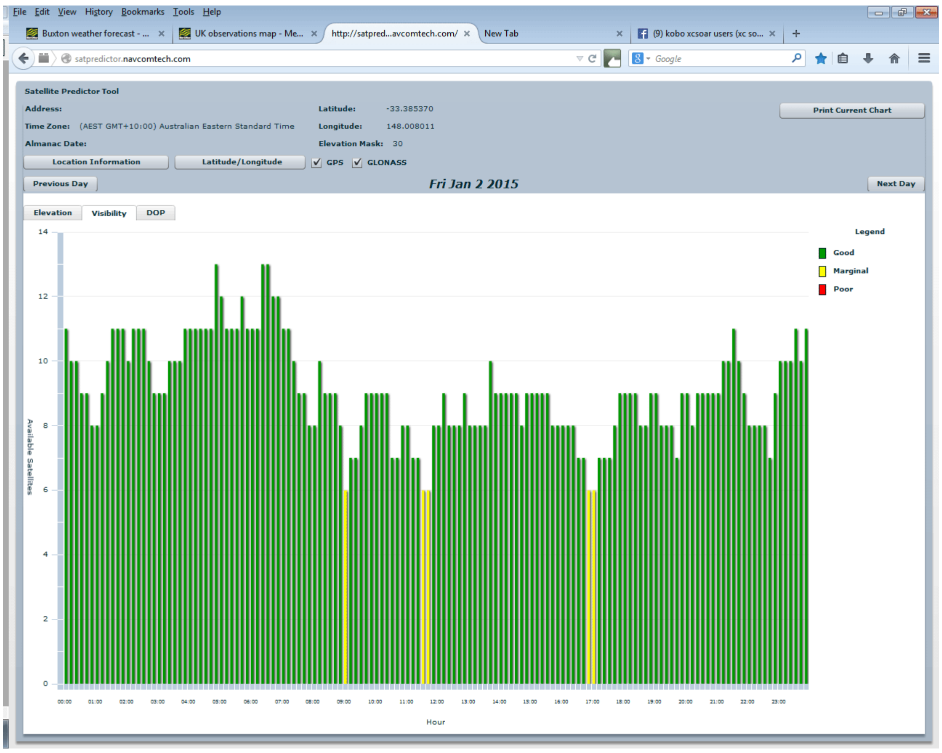


We are now down to only 3 satellites during some periods.

The predictor can also show the visibility of Glonass satellites. The following chart shows Glonass satellites for the same period with an elevation mask of 30 degrees.

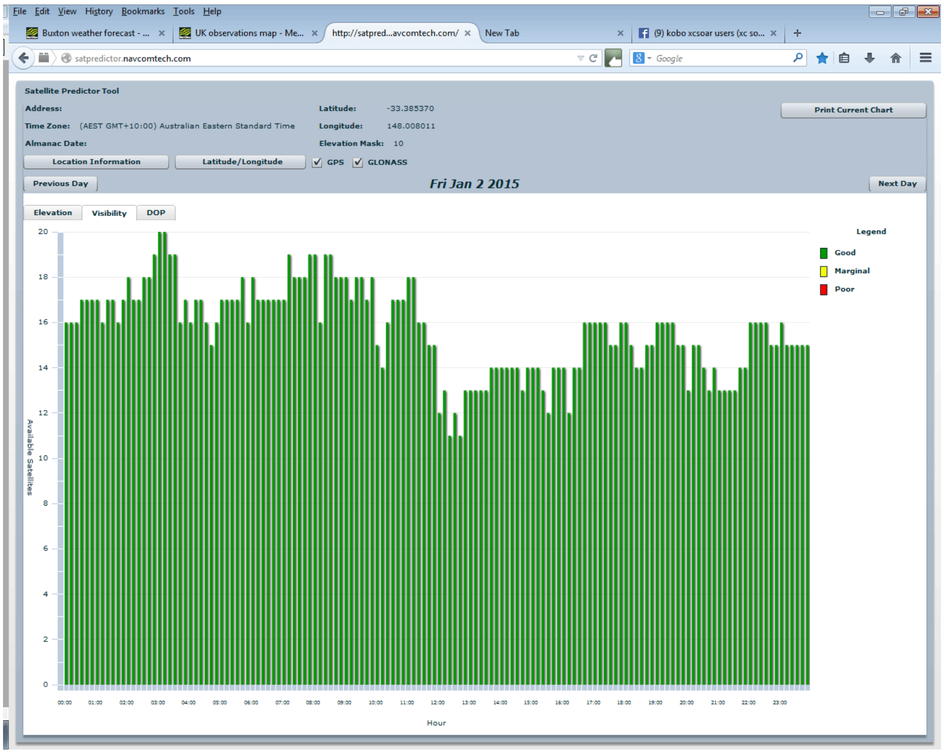


This looks just as bad, but the predictor can also show us GPS and Glonass added together.

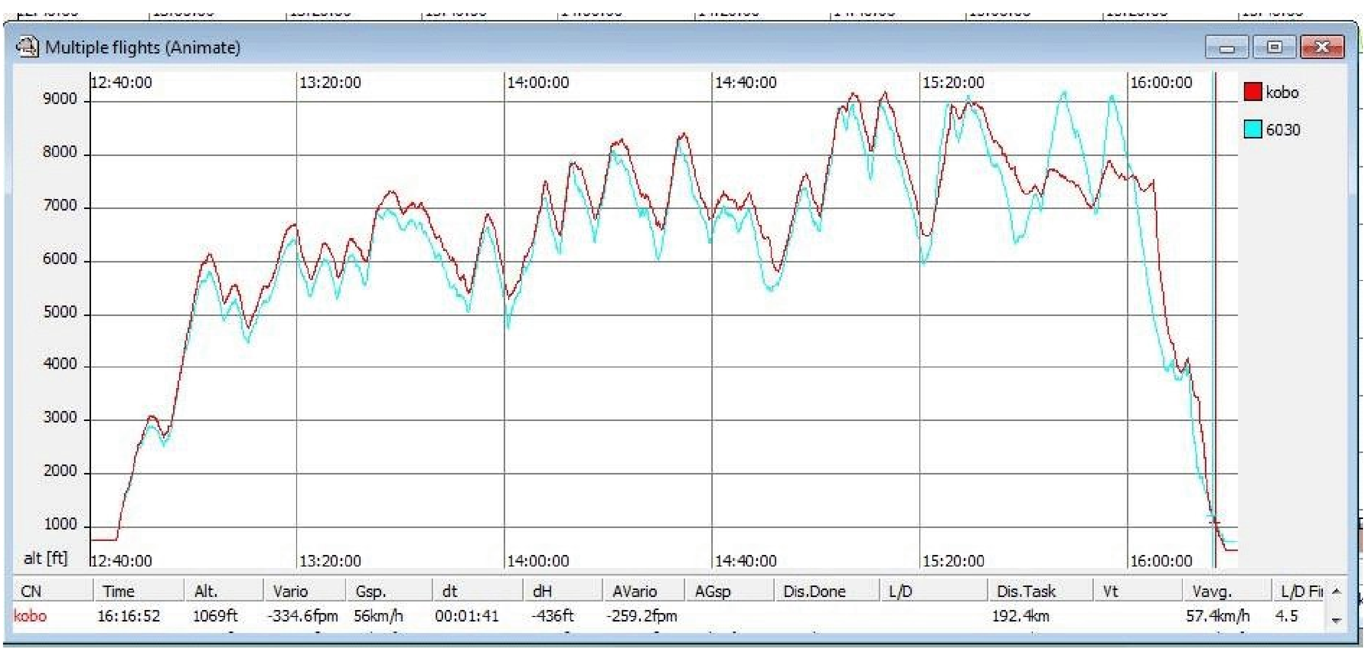


We now have “good” cover for most of the day with two “marginal” periods, but even in these we have a minimum of 6 satellites visible, all with an elevation of more than 30 degrees. Twice the number than with GPS alone.

Finally, retaining GPS with Glonass, but resetting the elevation mask to10 degrees we have what the predictor describes as "good" cover throughout the day.



A few days later another pilot had GPS altitude errors and managed to produce a comparative trace from his flight.



The red trace is GPS altitude from a PA6C module mounted on the front of a Kobo and the cyan is a barometric trace from a Flytech 6030. The failure of the GPS trace can be seen clearly just before 1600.

The pilots reporting problems were using Kobo/XCSoar units with Globaltop PA6H GPS modules. For a few pounds more Globaltop also make the GMS-G6 module which is similar but receives and uses Glonass satellites as well as GPS. An investigation into the performance of the GMS-G6 can be found at

http://www.50k-or-bust.com/Kobo XCSoar/Kobo XCSoar.htm

the results of which suggest that EM emissions from Kobo/XCSoar units significantly interfere with GPS and Glonass reception but that the use of GPS/Glonass receivers helps overcome this. If the pilots above had been using combined GPS/Glonass receivers they would probably not have had the problems they did.

When conditions are good there is probably little difference between the performance using GPS only or GPS with Glonass. Reception conditions vary rather more than we would like but when conditions are poor for whatever reason, the increased number of available satellites in the combined system helps considerably. Even so, I would still recommend that pilots use barometric altitude rather than GNSS altitude as inputs for glide calculations.