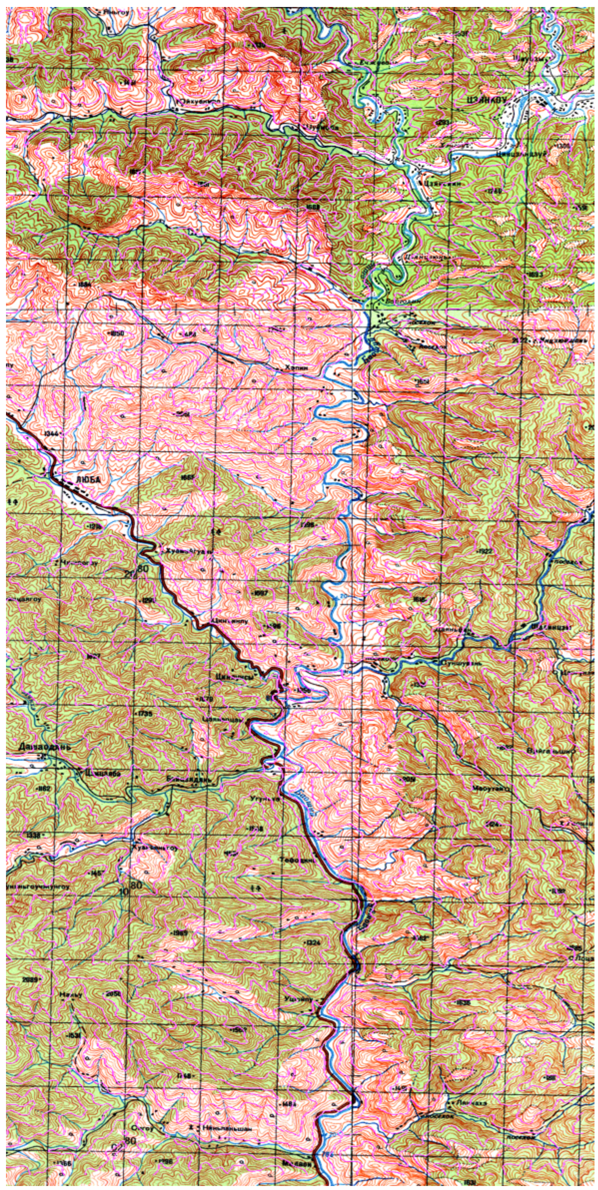
Note on the Russian Topographic Maps

The 1:100k Russian Topographic Maps for the study area have great detail and also record previous roads as well as features that will be useful in the data base. Hu reported that the image needed to be subset to the study area and there were issues with its projection and Datum (Gauss Kruger zone 18 with Pulkovo 1942 Datum and Krassovsky spheroid).

I made the subset and converted using ENVI “rigorous” method to Geographic coordinates. A Jpeg of the resulting image follows:



The contours are clear and the documentation says that the maps have 20m contours in flatter areas and 40m contours in mountains. The 40m contours have a "heavy" contour every 200m or 5 intervals.

I contoured SRTM data to the 200m contours and drew these on the Topographic map and the two did not seen to be consistent so I made a small study of the consistency between the data types we currently have. To do this I wrote an IDL program that extracts data from an image at each point of sets of points, lines, polygon and poly-lines.

1. Consistency of representation in SRTM data

The first test was to contour the SRTM data for the study area at contour intervals of 800m, 1000m, 1200m, 1400m and 1600m. These contours can be mapped onto SRTM or the Russian Maps or imported into Google Earth.

The new program was used to extract the data at the points of the contours to check the "jitter" in the essentially circular action. The variance within points that were supposedly on a single contour was about 20m for every contour. This is a function of the rapidly changing terrain. A table summarising the results follows:

Contour	Number	min	max	Mean	Sdev	CV(%)
800	1649	742.48	868.11	801.59	18.95	2.36
1000	7442	897.87	1093.37	1000.49	21.83	2.18
1200	9633	1116.08	1328.08	1199.94	22.24	1.85
1400	8522	1322.48	1498.41	1399.37	23.13	1.65
1600	4387	1523.19	1680.48	1598.91	22.13	1.38
1800	1089	1725.57	1853.81	1797.70	20.74	1.15

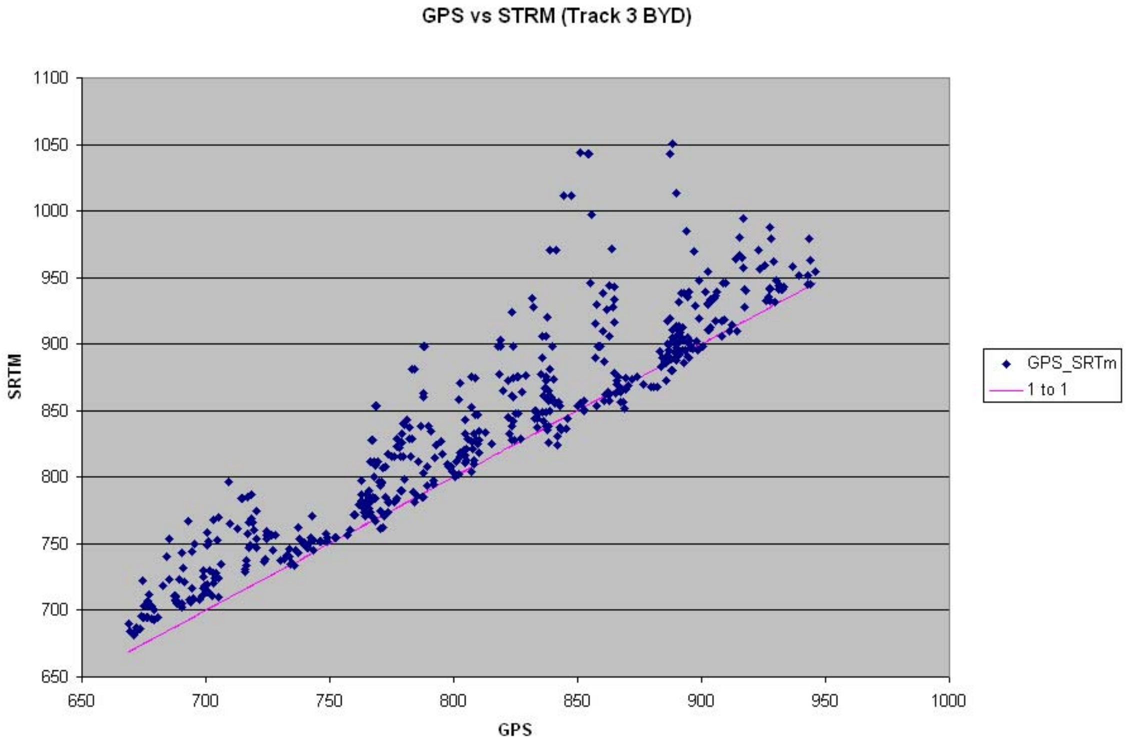
The minimum and maximum are at about 3 standard deviations indicating a generally random error of about 2%.

2. Consistency between GPS and SRTM data.

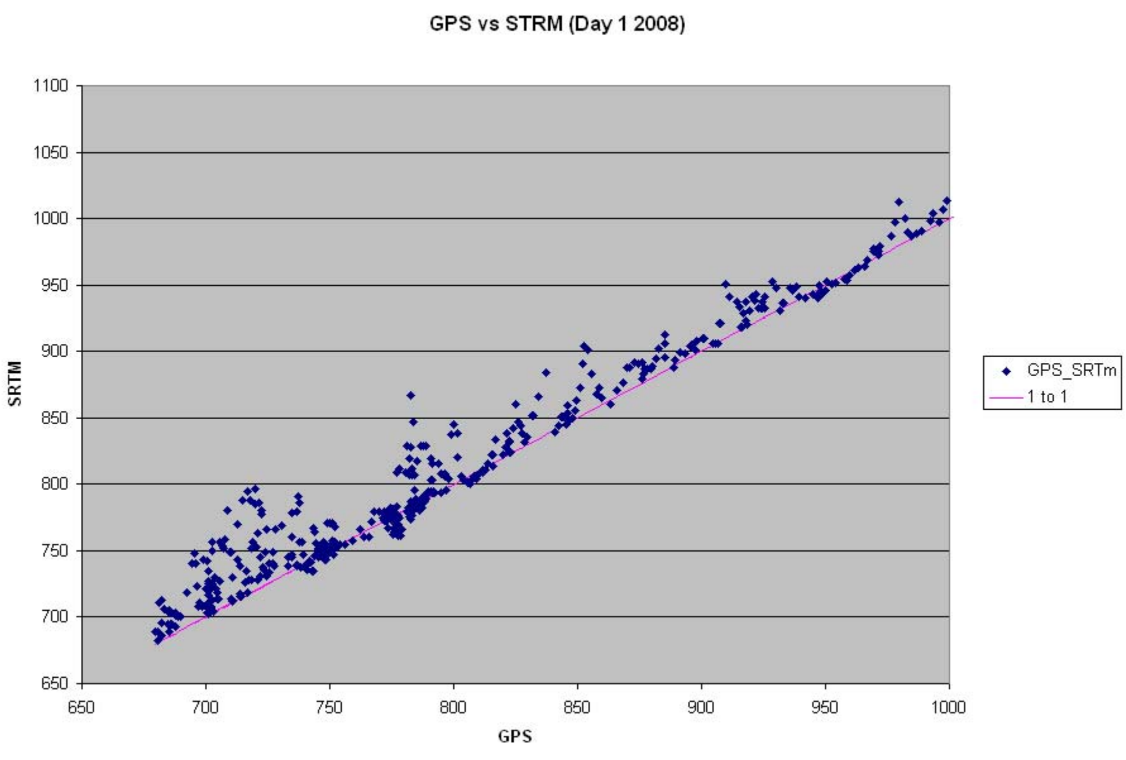
There were two GPS tracks running through the study area included in the data set. One was called "Track 3" and was taken on a run from Hanzhong to Yangling in 2006. The GPS was a Garmin GPSMap CSX and was put into the vehicle "skylight" area and had very good view of the sky. The other was taken on Day 1 of the visit to Chengdu and runs through the study area from Fengxian and Liuba.

The GPS track points have altitude data and the tracks were used with the new program to extract the corresponding SRTM altitudes and compare them. We will only compare them by graph since the statistics are affected by what we will find and maybe the graphs are better.

The first graph shows the "Track 3" data plotting SRTM against the GPS heights:



The other is the Day 1 (in October 2007, not 2008) of the visit to Sichuan. It plots as follows:



The purple lines shows “perfect” agreement. There are obviously many points where the SRTM data is plotting higher than the GPS but there is a also a baseline of consistent agreement between the data sets. This is good but not a surprise as SRTM works in the same geocentric frame as GPS and SRTM is based on satellite navigation.

There are more high points in the Track 3 data. These data are from the old Baoxie road across the Wulipo and through Taibai. There are steep ravines and many tunnes along this way.

I think the high points come about from three causes:

(i) GPS error

The GPS track for a moving vehicle in a mountainous area is not very accurate. The errors can easily be 15-20 metres or more. When the number of satellites in view decreases the accuracy reduces. The Garmin unit seems to extrapolate as well so that when only a few satellites of the constellation are visible there can be systematic errors as well. In these mountain areas, the roads are in valleys and so an error would take the point off the lowest and flattest area and normally increase the height as the track reached the hillsides.

(ii) Tunnels

Along this road there are many tunnels which are relatively short so that the GPS may extrapolate for some time before stopping due to lack of satellite coverage. The real surface will, of course be high above the GPS unit. The largest errors are probably tunnels. The Day 1 data shows how relatively few tunnels improves things.

(iii) SRTM valley filling

The SRTM is a side looking SAR radar. If there are insufficient look angles for an area the radar will tend to “fill in” ravines and steep valleys. I suspect many ravines along this road have been smoothed in this way. The SRTM data are generalised and so will have some valley filling due to that but the SRTM effect can be very severe for deep cuttings. This will also result in higher readings for the SRTM and GPS errors will move the point to higher (possibly much higher if the radar has few looks) ground much more quickly.

The Day 1 track is a good track. There were some deep valleys in the north at the start but generally the journey was through the widening Bao River valley. The GPS was also set up better with the aerial having good view of the sky and the track log being set to a faster sampling rate. It has far less issues than the track through the Baoxie Road area.

My conclusion is that the GPS and the SRTM are in good agreement and I was surprised that there was not more disagreement since they are at very different scales.

3. Consistency between SRTM and the Russian Topographic maps

The Russian Topographic maps are scanned paper maps. So to make a DEM from them the contours, spot heights, streamlines and other features need to be digitized. It seems unlikely it can be done automatically and I suspect the editing required to fix the problems would be as much effort as digitizing it all by hand. The job is very large and daunting!

In order to make a quantitative comparison I did two things:

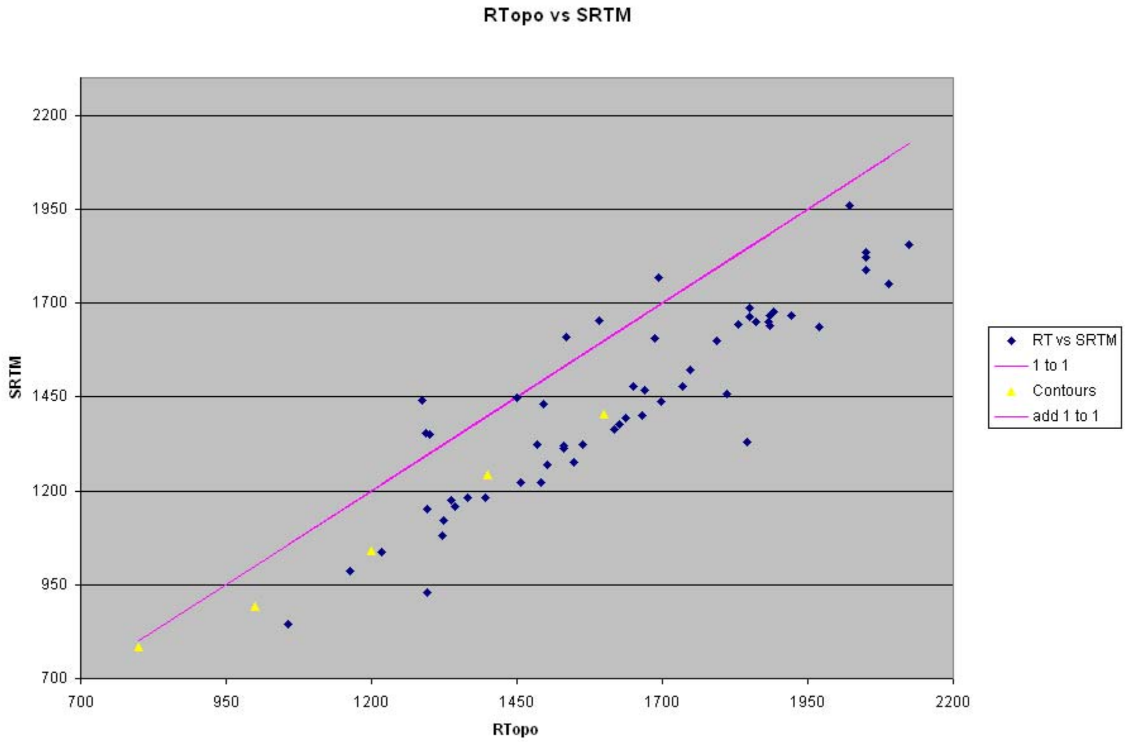
(i) Spot heights

I digitized the spot heights (mountain tops) from the Topographic map, converted the points to Geographical Coordinates and then extracted the SRTM data ate the same points. All were done. A typical Top Height point is shown below:

Because of problems to be discussed below, I located the Top Height points in the 1:200k Russian Topographic Maps and the ones that were also present in the 1:200k maps were identical in position and value – so the two series are consistent at least. In addition, I checked the contours on the basis that they are 40m steps and every 5 steps (200m) there is a thick line. By counting up to the Top Height it was clear the contours and Top Heights were consistent in the Topo maps.

(ii) Contours

I also digitized some contours (800m, 1000m, 1200m, 1400m and 1600m) near Madao and then extracted SRTM data for these points using the IDL program. It was laboriuous enough to do these so I became very concerned over the problems posed by extensive digitising!



The results can be combined into one plot and are a worry! Except for a few points, the SRTM data plot almost 200m lower than the Russian Topo Maps. They seem to come together near 800m but there were not enough data taken to fully test. The contour data (in yellow) are the average of the SRTM on the contour and they plot consistently with the spot height data (the blue diamond shaped points). This seems to be a systematic effect and needs to be resolved. You would expect the SRTM to be lower due to generalisation and also if an error is made it will be to miss the high point so the errors are expected to be the opposite of what was found in the deep valleys. But 200m is a bit large.

The cause may be datum or level as it I not clear what datum, baseline or levelling was used to get altitudes for these maps. It could also be an “error” of labelling as the mean values for the contours were as follows:

Mean	Stdev	contour
784.18	23.86	800
890.93	53.68	1000
1039.83	58.00	1200
1242.90	57.90	1400
1404.92	47.42	1600

The SRTM means are very close to 800, 900, 1000, 1200 and 1400 which would obtain if the 20m contours changed to 40m contours after 1000m and the 2000m is just bad tagging. But maybe the numbers are a coincidence. I think a more extensive test is needed. But I know how tedious it is to digitise contours and do not wish it on anyone.

4. Conclusions

My conclusions are that GPS and SRTM (ie Google Earth) can be matched quite well and are consistent in baseline and magnitude. However, it is not clear what the big difference in heights is due to. It is too hard to explain by the previous reasons. Certainly, SRTM is a coarser scale but that tends to affect the slopes and curvatures more than the heights. The "filling in" of ravines by SRTM is not the problem as SRTM should map hilltops ver accurately. Datum changes and baselines are the most likely cause and I will pursue them.

I had been looking at other options for at least a smaller portion of the site or how to combine data from valleys with a more general data set. But I will not spend time on those searches until we have found wha is going on with the heights.

In the meantime, I think this gives support to the proposal to go ahead with a phase I of the pilot in which SRTM, visual images based on the Russian Topo maps and integrated into GE and other data are used as the base. 3D visualisation is quite possible except that it will not be as detailed as will eventually be needed by the museum.

DLBJ
April 2008.