Survey of Moelwyn Mawr North Ridge Top

16 June 2015

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1) Introduction

Moelwyn Mawr North Ridge Top (Hill Number 2023, Section 30B, OS 1:50000 Map 115, OS 1:25000 Map 17W & 18W, Grid Ref. SH660452) is listed as a Nuttall (a hill in England and Wales at or over 2000ft in height and with 15m or more of drop) in the Database of British and Irish Hills (DoBIH) with just 15m of drop. On the 1:50k map the hill appears as a single ring contour linked to its parent, Moelwyn Mawr, by a relatively broad bwlch in both the valley to valley direction and hill to hill direction. Thus the drop could well be just less than 15m which would result in the hill being removed from the list of Welsh Nuttalls. However, there have been several surveys with simple levels which indicate that the drop is just over 15m, the range being 15.2m to 15.6m. In this technique a staff is held vertically with a spirit level affixed to it at a specific measured height to gauge where on the hillside the top of the spirit level reaches. The surveyor then moves to this point and repeats the process to the summit and the accumulated measured height gain gives the drop. The position of the bwlch is estimated, as is the position of the summit if this is not obvious. The measurement uncertainty of these techniques is about 1-2m, which is greater than the amount by which the determinations have exceeded 15m. Consequently, the purpose of this survey was to measure accurately the drop for Moelwyn Mawr North Ridge Top to determine if it attains 15m or not and thereby resolve its classification.

2) Equipment used and Conditions for Survey

A Leica NA730 Professional Automatic level (X30 telescopic system)/tripod system and a "1m" **E**-staff extendable to 5m were used to determine the positions of the bwlch and summit, and also to line survey between these two points.

Absolute heights were measured using a Leica Viva GS15 and Trimble GeoXH 6000 GNSS receivers. These receivers are dual-frequency, multi-channel instruments, which means they are capable of locking on to a maximum of 12 GPS and 8 GLONASS satellites as availability dictates, and receiving two signals (at different frequencies) from each of these satellites. The latter feature reduces inaccuracies that result from atmospheric degradation of the satellite signals. As stand-alone instruments they are capable of giving position and height to an accuracy of about two metres and five metres respectively. Note that small hand-held GPS receivers used for general navigation can only receive up to 12 GPS satellites and each at a single frequency and therefore these instruments have a poorer positional accuracy of +/-5metres and a height accuracy of no better than +/-10 metres. Some recently produced hand held GPS Garmin receivers can also receive signals from GLONASS satellites which greatly improve the speed at which these units can achieve a satellite "fix". Despite the on-board features of the GS15 and GeoXH 6000 receivers, there are still sources that create residual errors. To obtain accurate positions and heights, corrections were made to the GNSS (Global Navigation Satellite System) data via imported RINEX data from Ordnance Survey which were post-processed using Leica GeoOffice 8.3 and Trimble GPS Pathfinder Office respectively. Repeated measurements with the GeoXH 6000 instrument made on the same point

give a height precision of +/-0.20m; height precision for the GS15 using the same method is +/-0.05m.

Conditions for the survey, which took place between 11.30hr and 16.00hr BST, were poor for the time of year. The weather was cold, 11 degrees Celsius with the wind speed measured as 20mph gusting to over 30mph. Visibility was poor with cloud covering the summit intermittently for the duration of the survey. Fortunately, the individual legs of the line survey were short so that the scale on the staff was easily read through the optical level despite the conditions. There was also sufficient shelter from the wind while waiting for the GNSS receivers to collect data. The weather forecast had been for warm sunshine. A photograph of the hill taken by Myrddyn Phillips on a previous occasion is shown in Appendix 1.

3) The Survey

3.1) Character of Hill

The Moelwyn Hills (Moelwynion) lie just to the West of Blaenau Ffestiniog and are well known for their rugged terrain and industrial past. The area is covered with abandoned slate workings, two of which, Gloddfa Ganol and Llechwedd are tourist attractions. Despite the spoil heaps of waste slate, the landscape is sufficiently grand that these do not impact significantly upon it. All of the hills here are imposing with the view of Cnicht from the A4805 just North of Garreg even being likened by some to that of The Matterhorn from Zermatt.

The Moelwyns may be approached from Blaenau Ffestiniog by a path that bifurcates about 1km from the road. The left branch rises to the dam of Llyn Stwlan and from there to the bwlch between Moelwyn Bach and Craigysgafn. The right branch rises and bifurcates again after 0.5km, the left branch traversing above Llyn Stwlan to the bwlch between Moelwyn Bach and Craigysgafn while the right hand branch takes the walker to the bwlch between Moelwyn Mawr and Moel-yr-hydd. The route to the bwlch between Moelwyn Mawr and Moel-yr-hydd is the more direct for the North Top, the summit being about 0.5km away over pathless but good terrain with 100m of ascent.

While these routes are direct, a better although slightly longer route starts from the tiny village of Croesor where there is a walkers' car park. The village is located about 3km West of Moelwyn Mawr. From here the road goes NE for about 0.5km where it splits into three landrover tracks. The right-hand one is taken and this rises gradually up the NE flank of Moelwyn Mawr and terminates at derelict slate workings at 480m. From here a faint path winds its way East to the North ridge of the mountain where a short walk over steep terrain brings one to the rocky summit of Moelwyn Mawr North Ridge Top. This was the route we took for this survey.

3.2) Summary of Survey Method

Upon arrival at the summit it was quickly established that the highest point was an outcrop of rock. The survey then commenced at the bwlch whose position was identified with the Leica NA730 level and staff and marked with a flag. A line survey was next carried out from here to the summit and then repeated back to the bwlch. Finally, data were collected with the Leica Viva GS15 and the GeoXH 6000 at the summit and with the Leica Viva GS15 at the bwlch.

3.3) The Bwlch & Line Survey

The first task was to carry out a visual assessment of the bwlch area which was well defined and comprised short-cropped turf. This resulted in the placement of four flags two in the valley to valley direction and two in the hill to hill direction, which roughly defined the area in which the bwlch lay. This rectangle was approximately 10m x 5m. Next the Leica NA730 was set up at a convenient position and staff readings taken in three lines in the hill to hill direction and three lines in the valley to valley direction (all about 3m apart) forming a small grid from which the bwlch position was located to within two metres. A final few staff placements then located the position of

the bwlch to less than one metre. This lay within the rectangle previously marked out. The bwlch position was marked with a flag and a surveyors bolt.

Next a line survey from the bwlch to the summit was carried out. The Leica NA730 level was set up on the tripod at a convenient position near to the bwlch and staff readings were taken with the staff set up on the bwlch position. Once this set of readings had been taken (Backsights BS) the staff was then moved to an uphill position, but the level not moved apart from a rotation through 180 degrees, to take another set of readings (Foresights FS). The line survey route then continued towards the summit. This process of alternately moving the staff and level was repeated until the final reading was taken with the staff on the summit position. Readings were taken from the horizontal and also the lower and upper stadia lines of the level to provide a check on any staff misreadings and to improve accuracy. If in any set of three readings the average was greater than 1mm different from the horizontal reading, then that set was re-measured. The line survey readings are given in the Appendix 2. Once completed the line survey was then repeated, this time going from the summit to the bwlch and using exactly the same method as just described. The line survey readings are again given in Appendix 2.

The drop measured by the line surveys is 14.767m with a closing error of 3mm.

We also decided to measure the drop by collecting GNSS data for the summit and the bwlch. The tripod was set-up over the bwlch position and the Leica Viva GS15 was then fixed to it with a clamp and tribrach (the "short tripod" configuration). The height of the receiver above the ground was then measured with the integral tape. The vertical offset from measuring point to the ground was 0.612m (see photograph in Appendix 1) plus 0.255m for the tribrach/hook system. GNSS data were collected for 60min with an epoch time of 15 seconds.

The data for the Leica Viva GS15 were processed in Leica GeoOffice 8.3 using the six nearest base stations. The results are given in the table below:-

System	Easting	error(1SD)	Northing	error(1SD)	Height(m)	error(1SD)
GS15	266085.620	0.004	345195.205	0.002	634.952	0.012

The height of the bwlch is 634.95m

3.4) The Summit

As previously described the summit was readily identified as an outcrop of rock on which there were several candidate highest points although all were just within a few mm in height of one another. First, the Leica NA730 level was set up adjacent to the outcrop and the exact summit position on it found with the staff and marked. Then the tripod was set up over the summit position and the Leica Viva GS15 fixed to it with a clamp and tribrach (the "short tripod" configuration). The height of the receiver above the ground was then measured with the integral tape. The vertical offset from measuring point to the summit of the rock was 0.322m (see photograph in Appendix 1) plus 0.255m for the tribrach/hook system. GNSS data were collected for 60min with an epoch time of 15 seconds.

Finally, the Trimble GeoXH 6000 was placed on the top of the rock and GNSS data were then collected for 5 minutes once the receiver accuracy measurement had reached 0.1m.

The data for the Leica Viva GS15 were processed in Leica GeoOffice 8.3 using the six nearest base stations and the Trimble GeoXH 6000 data were processed in Trimble GPS Pathfinder Office using the five nearest base stations. The results are given in the table below:-

System	Easting	error(1SD)	Northing	error(1SD)	Height(m)	error(1SD)
GS15	266096.347	0.005	345255.626	0.002	649.723	0.007
Trimble GeoXH 6000	66096.389		45255.892		649.672	

The height of Moelwyn Mawr North Ridge Top = 649.723m

The drop as determined by the bwlch and summit heights is 649.723 - 634.952 = 14.771m

4) Summary of Operating Conditions

	GS15	GeoXH 6000
Data Collection bwlch (min)	60	5
Data collection summit (min)	60	5
Number of Base Stations used in Processing for all points	6	5
Epoch Time (sec)	15	1
Tropospheric Model	Computed	Unknown
Cut off Angle (degs)	15	5

5) Discussion of Results

The closing error (the difference between the bwlch to summit drop measurement and the summit to bwlch drop measurement) of 0.003m is excellent and gives a very high degree of confidence in the result.

For the GNSS results from the Leica Viva GS15, a one hour data collection time gives results with a measurement uncertainty of +/-0.06m. This measurement uncertainty applies to both the bwlch and summit measurement. In addition the measurement uncertainty associated with the location of the bwlch is +/-0.01m as determined by the staff measurements. The summit position was found to better than 0.005m of height. Therefore the overall measurement uncertainty for the GNSS determination of drop from the Leica Viva GS15 is +/-0.09m [square root (0.06^2 +0.06^2 + 0.01^2 +0.005^2)]. The drop is therefore 14.77m+/-0.09m as determined by the Leica Viva GS15.

The uncertainties described above for the locations of the summit and bwlch also apply to the line survey. For each set of readings taken from the staff we would estimate an uncertainty of +/-

0.001m. Also on the two line surveys there are imbalances in the total foresight and backsight readings of about 15m and 25m respectively. As the NA730 is calibrated to height tolerance within 0.003m over a distance of 30m , the uncertainty associated with the complete set of measurements in each line survey is +/-0.004m [square root ($7x0.001^2 + 0.003^2$)].Therefore the overall uncertainty in the drop measurement from the line survey is +/-0.01m [square root ($0.004^2 + 0.01^2 + 0.005^2$)]. All measurement uncertainties are to 99.8% confidence (3 standard deviations).

6) Summary and Conclusions

The **summit** of **Moelwyn Mawr North Ridge Top** is at grid reference * SH 66099 45259 and is a pointed rounded rock. Its height is **649.7+/-0.06m**.

The **bwlch** of **Moelwyn Mawr North Ridge Top** is at * SH 66089 45199 and is unfeatured ground on short-cropped turf. Its height is **635.0+/-0.06m.**

The **drop** for **Moelwyn Mawr North Ridge Top** is **14.77+/-0.01m** as determined by the line survey and therefore we recommend that the hill be removed from the Nuttall's list of 2000ft hills with a minimum of 15m of drop.

- NB: Grid references "corrected" to Garmin are quoted in the summary.

John Barnard, Graham Jackson and Myrddyn Phillips, 20 June 2015

Appendix 1

Moelwyn Mawr North Ridge Top

Offset for Leica Viva GS15 set-up at summit

Leica Viva GS15 on summit

The Leica Viva GS15 collecting data at the bwlch as seen from the lower slopes of Moelwyn Mawr North Ridge Top

Offset for Leica Viva GS15 set-up at bwlch

Appendix 2

Title:- Moelwyn Mawr North Ridge Top

Instrument Leica NA730 **Date:-** 16-Jun-15

	Horizontal Line			Lower Stadia Line			Upper Stadia Line							
Point Number	Backsight R	Foresight F	Height H	Backsight R	Foresight F	Height H	Backsight R	Foresight F	Height H	Mean BS	Mean FS	Height Difference	BS Distance	FS Distance
	metres	metres	metres	metres	metres	metres	metres	metres	metres	metres	metres	metres	metres	metres
Bwlch to Summit : GVJ Level, MP Staff and JB Data recording														
1	2.225	0.378		2.175	0.340		2.275	0.416		**2.225**	**0.378**		10.000	7.600
2	2.301	0.313		2.263	0.272		2.340	0.355		**2.301**	**0.313**		7.700	8.300
3	2.638	0.230		2.597	0.196		2.678	0.264		**2.638**	**0.230**		8.100	6.800
4	2.608	0.728		2.552	0.688		2.663	0.768		**2.608**	**0.728**		11.100	8.000
5	2.755	0.243		2.708	0.220		2.802	0.264		**2.755**	**0.242**		9.400	4.400
6	2.219	0.156		2.197	0.133		2.242	0.178		**2.219**	**0.156**		4.500	4.500
7	2.398	0.328		2.368	0.321		2.427	0.336		**2.398**	**0.328**		5.900	1.500
									Sum =	**17.144**	**2.376**	**14.768**	**56.700**	**41.100**
Summit to Bwlch : GVJ Level, MP Staff and JB Data recording														
1	0.328	2.912		0.321	2.881		0.336	2.943		**0.328**	**2.912**		1.500	6.200
2	0.986	2.692		0.958	2.648		1.014	2.737		**0.986**	**2.692**		5.600	8.900
3	0.547	3.655		0.507	3.580		0.587	3.730		**0.547**	**3.655**		8.000	15.000
4	0.604	2.727		0.565	2.665		0.645	2.788		**0.605**	**2.727**		8.000	12.300
5	0.597	3.650		0.549	3.599		0.645	3.701		**0.597**	**3.650**		9.600	10.200
6	0.532	2.724		0.502	2.665		0.562	2.784		**0.532**	**2.724**		6.000	11.900
									Sum =	**3.595**	**18.360**	**-14.765**	**38.700**	**64.500**