

# Survey of Carnedd y Ddelw

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## **1) Introduction**

Carnedd y Ddelw (Hill Number 2011, Section 30B, OS 1:50000 Map 115, OS 1:25000 Map OL17E, Grid Ref. SH708705) is listed as a Nuttall (a hill with greater or equal to 15m of drop and 2000ft or greater in height) in the Database of British and Irish Hills (DoBIH). From map contours the bwlch appears to be very broad, being approximately 150m in both the hill to hill direction and the valley to valley direction. On the 1:10k & 1:25k maps there is a 673m spot height in the approximate centre of this area (SH 7086 7030) near a fence that runs in the hill to hill direction. The summit has a spot height of 688m at SH 7078 7055 giving a drop of 15m. Thus, Carnedd y Ddelw just qualifies as a Nuttall according to the map.

Recently Aled Williams conducted a LIDAR (Light Detection And Ranging) study of Carnedd y Ddelw and determined the drop to be 13.6m thus suggesting that the hill should be removed from the list of Nuttalls.

The purpose of this survey was to measure accurately the drop of Carnedd y Ddelw 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.

Absolute heights were measured using a Leica Viva GS15 receiver. This receiver is a dual-frequency, multi-channel instrument, which means it is 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 a stand-alone instrument, it is 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 +/-5 metres 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 Leica Viva GS15 receiver, 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. Repeated 1hr measurements with the Leica Viva GS15 on the same position give a height precision of +/-0.06m (to three standard deviations).

Conditions for the survey, which took place between 11.30hr and 17.00hr BST, were fair. The weather was cool, 12 degrees Celsius, with sunshine for most of the survey, thus giving excellent visibility for line surveying. However, there was a strong wind of 40mph gusting to 45 – 50 mph on occasions, which caused vibration of both the level and the staff. Consequently, this lengthened the time of the line survey considerably.

### **3) The Survey**

#### **3.1) Character of Hill**

Carnedd y Ddelw lies in the northern Carneddau and is the last 2000ft summit on the curving ridge that descends from Foel Fras over Drum and eventually down to the small village of Abergwyngregyn on the main A55 road to Anglesey. This ridge offers an easy route to the summit, but an even shorter approach is from the end of the minor road that rises from the Conway Valley through the village of Llanbedr-y-cennin to terminate in a small car park at 420m height beneath Tal-y-Fan at SH720715. From the car park the road continues as a track and after about 700m passes through a gate in a wall. Here a path leaves the track and rises south-west and then finally south-east by a fence to the summit, a climb of just 270m. The summit area comprises a very large hollowed-out cairn which forms an excellent wind-shelter. According to 'The Mountains of England and Wales' by John and Anne Nuttall, a golden figure was found here when the cairn was excavated in the eighteenth century. About 30m further SE there is a rocky knoll which to the unaided eye appears to be the summit. From the summit, it is a short distance of about 250m along a faint path by the fence to the broad col. In addition to the large area it occupies, there are areas of thick heather and tussock grass and confusing undulations in the ground.

#### **3.2) Summary of Survey Method**

Upon arrival at the bwlch it was quickly realised that a significant amount of time would be required to determine its exact position. It was neither well defined in the valley to valley direction nor in the hill to hill direction thanks to the confusing undulations and the areas of thick vegetation. A strategy was required to find its exact position. The summit posed less of a problem in that its position was either on the rocky knoll or under the loose stones of the windshelter. We decided to start on the summit as this would be more straightforward to determine.

#### **3.3) Finding the Summit and Bwlch Positions**

The tripod was set-up close to the summit of the rocky knoll and a staff reading was taken on the summit rock. A staff reading was then taken on the natural ground at the base of the windshelter at its highest point near the fence. Finally, a staff reading was taken on the loose stones within the windshelter.

Staff reading on top of rocky knoll = 0.553m

Staff reading on natural ground at base of windshelter = 1.66m

Staff reading on loose stones inside windshelter = 0.88m

Since the lower the staff reading then the higher the feature, it is clear that the rock on the highest point of the knoll is the summit.

Next our attention focussed on the bwlch. Ground close to its southern edge, just before the ascent to Drum, was one candidate for the bwlch position that was identified by a visual inspection, while another candidate was about 50m North of this position, where a slight depression crossed the bwlch in the valley to valley direction. Two lines of flags were next laid at each site in the valley to valley direction and staff readings taken of each. This preliminary work showed that the candidate bwlch position at the foot of the ridge to Drum was about 1m higher than the candidate 50m to the North.

Next, our attention was focussed on this northern area. Two more lines of flags were laid one 10m to the North and one 10m to the South of the original line of flags and staff readings were taken from each of these. From this work, the bwlch was identified finding the flag that gave the lowest staff reading in the valley to valley direction but the highest staff reading in the hill to hill direction. This position was then marked with a different coloured flag to identify it as the bwlch position.

### 3.4) The Line Survey

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 13.97m with a closing error of 9mm.

### 3.5) The Bwlch & Summit Height Determinations

In addition to the line survey it was also decided to measure the height of the summit and the bwlch with the Leica Viva GS15 GNSS receiver. Since the line survey concluded at the bwlch, data were collected here first. The tripod was set up over the bwlch 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 ground was 0.508m (see photograph in Appendix) plus 0.255m for the tribrach/hook system. GNSS data were collected for 45min with an epoch time of 15 seconds.

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

#### **Bwlch**

System	Easting	error(1SD)	Northing	error(1SD)	Height(m)	error(1SD)
Leica Viva GS15	270871.236	0.001	370326.319	0.002	672.028	0.004

The height of the bwlch of Carnedd y Ddelw = 672.0m

Next our focus switched to the summit. 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). Here the wind was causing a problem as it was in danger of knocking over the tripod, which would have resulted in the GS15 falling on to rock just beneath the summit. Consequently, several large rocks were collected and used to weigh down the tripod and stabilise it. 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 0.264m (see photograph in Appendix 1) plus 0.255m for the tribrach/hook system. GNSS data were collected for 45min with an epoch time of 15 seconds.

### Summit

System	Easting	error(1SD)	Northing	error(1SD)	Height(m)	error(1SD)
Leica Viva GS15	270811.262	0.002	370531.670	0.002	685.999	0.010

The height of the summit of Carnedd y Ddelw = 686.0m

The drop as determined by the bwlch and summit heights is  $685.999 - 672.028 = 13.971\text{m}$

### 4) Summary of Operating Conditions

	GS15
Data Collection bwlch (min)	51
Data collection summit (min)	48
Number of Base Stations used in Processing for all points	7
Epoch Time (sec)	15
Tropospheric Model	Computed
Cut off Angle (degs)	15
Geoid Model	OSGM15

### 6) LIDAR Analysis

LIDAR analysis of Carnedd y Ddelw was performed by Aled Williams on 8 November 2016.

LIDAR data was obtained from <http://lle.gov.wales>, courtesy of Welsh Government/Natural Resources Wales (public sector information licensed under the Open Government Licence v2.0), with the elevation modelled via the Digital Surface Model (DSM). The data was processed using geographic information system software and EPSG: 27700 as the coordinate reference system.

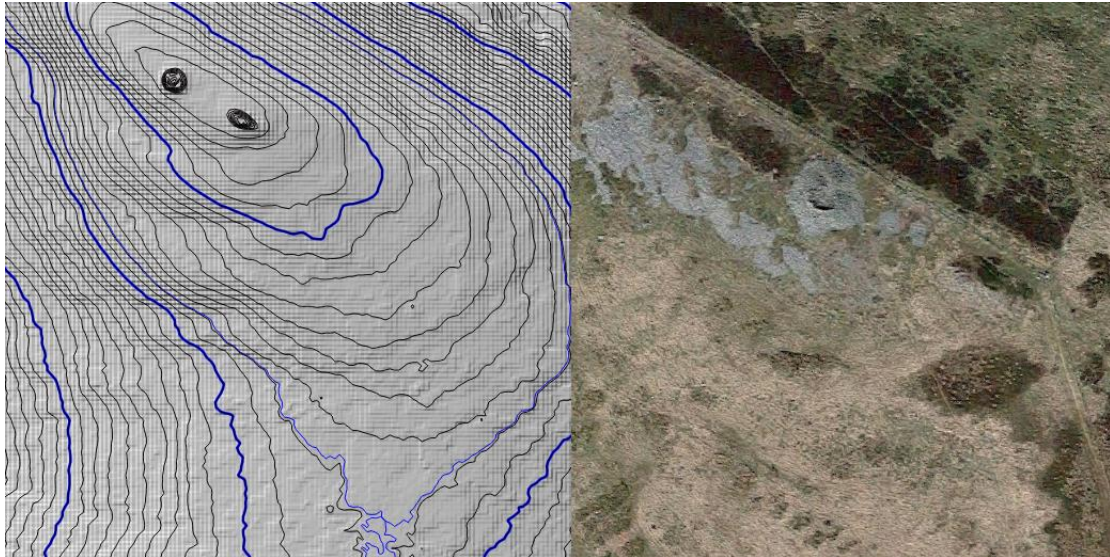


Figure 1: Topography of Carnedd y Ddelw processed from LIDAR data (left). Aerial view of summit (right; not to LIDAR scale).

Summit Name: Carnedd y Ddelw

Summit Height: 685.72m

Summit Grid Reference: SH 70811 70531

Bwlch Height: 672.11m

Bwlch Grid Reference: SH 70872 70357

Drop: 13.61m

LIDAR Model: DSM

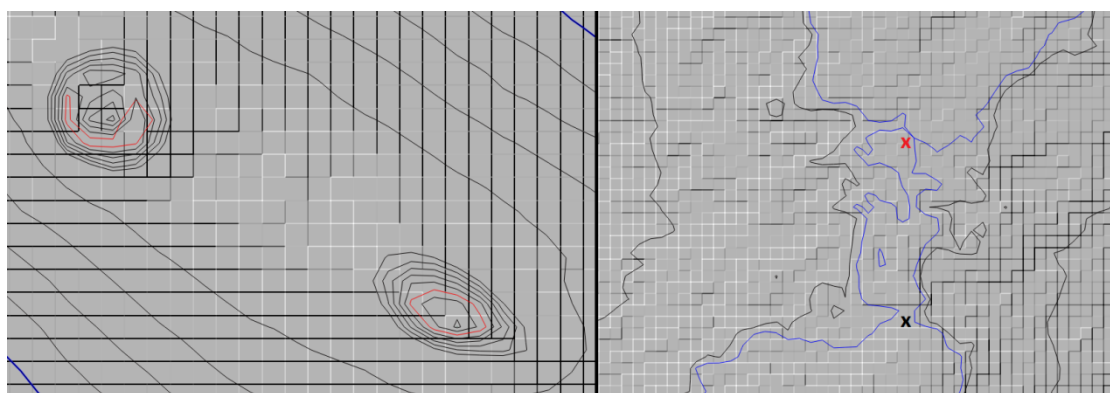


Figure 2: Summit (left) and bwlch (right) topography of Carnedd y Ddelw processed from LIDAR data. Red contour represents elevation of 685.5m (left image). Blue contour represents elevation of 672.11m (right image). The red cross is the LIDAR bwlch at an elevation of 672.11m, with the black cross being the level-and-staff/Leica GS15 bwlch, which LIDAR gives at an elevation of 672.13m.

## 7) Discussion of Results

For the GNSS results from the Leica Viva GS15, a 45min data collection time gives results with a measurement uncertainty of  $\pm 0.06\text{m}$ . This measurement uncertainty applies to both the bwlch and summit measurement. In addition the measurement uncertainty in height associated with the location of the bwlch is  $\pm 0.2\text{m}$  as determined by the staff measurements. The summit position was found to within  $\pm 0.02\text{m}$  of height. Therefore the overall measurement uncertainty for the GNSS determination of drop from the Leica Viva GS15 is  $\pm 0.22\text{m}$  [square root ( $0.06^2 + 0.06^2 + 0.2^2 + 0.02^2$ )]. The drop is therefore  $685.998 - 672.027 = 14.0 \pm 0.20\text{m}$  as determined by the Leica Viva GS15. Similarly the overall measurement uncertainty as determined by the line survey is: [square root( $0.009^2 + (0.2)^2 + (0.02)^2$ )] =  $0.20\text{m}$ . Note that the measurement uncertainty is dominated by the uncertainty in the determination of the bwlch position, which is due to the vegetation and undulating nature of the terrain.

The LIDAR analysis places the summit at SH 70811 70531 which is identical to the position found in the survey. There is a 0.3 difference in the height determination (686.0m GS15 vs 685.7m LIDAR). The bwlch position found from the LIDAR analysis is SH 70872 70357 which is 30m North of the position found in this survey of SH 70871 70326. We determined the ground to be clearly rising at the LIDAR position. However, the height difference of just 0.1m (672.0m GS15 vs 672.1m LIDAR) shows good agreement and illustrates the challenge offered by the thick vegetation cover. For example, measurement from the 1:10k map shows the spot height on the bwlch at SH 70867 70312 just 15m South of the surveyed position.

## 8) Summary and Conclusions

The **summit** of **Carnedd y Ddelw** is at grid reference \* SH 70814 70535 and is a rock on a knoll about 40m SE of a large windshelter. Its height is **686.0m  $\pm$  0.06m**.

The **bwlch** of **Carnedd y Ddelw** is at \* SH 70874 70329 and is unfeathered ground. Its height is **672.0  $\pm$  0.2m**.

The **drop** for **Carnedd y Ddelw** is **14.0  $\pm$  0.22m** and consequently **Carnedd y Ddelw** does not have sufficient drop to be classified as a Nuttall. The result has since been accepted by John & Anne Nuttall and Carnedd y Ddelw has been removed from their list of 2000ft mountains of England and Wales.

- NB: Grid references for Garmin receivers are quoted in the summary.

John Barnard, Graham Jackson and Aled Williams, 21 May 2017



## Appendix 1



**The summit of Carnedd y Ddelw with the large hollowed out cairn in the background**



**General view of bwlch with the Leica Viva GS15 and some of the flags just visible**



**Offset for Leica Viva GS15 set-up at summit**



**Offset for Leica Viva GS15 set-up at bwlch**



## Appendix 2

**Title:-** Carnedd y Ddelw

**Instrument:-** Leica NA730

**Date:-** 05-May-17

	Horizontal Line			Lower Stadia			Upper Stadia							
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
<b>Col to Summit (JB Level and GJ Staff)</b>														
1	1.415	1.523		1.301	1.402		1.530	1.645		1.415	1.523		22.900	24.300
2	0.950	0.376		0.736	0.286		1.161	0.466		0.949	0.376		42.500	18.000
3	3.131	0.122		2.954	0.080		3.305	0.164		3.130	0.122		35.100	8.400
4	3.725	0.145		3.560	0.098		3.888	0.193		3.724	0.145		32.800	9.500
5	2.792	0.313		2.694	0.258		2.889	0.365		2.792	0.312		19.500	10.700
6	2.168	0.508		2.101	0.470		2.235	0.546		2.168	0.508		13.400	7.600
7	1.705	0.380		1.656	0.324		1.756	0.436		1.706	0.380		10.000	11.200
8	2.004	0.545		1.973	0.527		2.034	0.564		2.004	0.545		6.100	3.700
									Sum =	17.888	3.912	13.976	182.300	93.400
<b>Summit to Col (GJ Level and JB Staff)</b>														
1	0.545	2.451		0.527	2.391		0.564	2.512		0.545	2.451		3.700	12.100
2	0.512	1.788		0.574	1.686		0.447	1.888		0.511	1.787		-12.700	20.200
3	0.265	2.605		0.222	2.489		0.308	2.724		0.265	2.606		8.600	23.500
4	0.183	2.750		0.146	2.656		0.220	2.848		0.183	2.751		7.400	19.200
5	0.388	2.678		0.352	2.578		0.425	2.779		0.388	2.678		7.300	20.100
6	0.142	2.731		0.099	2.585		0.185	2.875		0.142	2.730		8.600	29.000
7	0.406	1.401		0.373	1.058		0.438	1.749		0.406	1.403		6.500	69.100
									Sum =	2.440	16.407	-13.967	29.400	193.200