The Transition to High Resolution Digital Surface Models: Improvements in Visibility Analysis Performance

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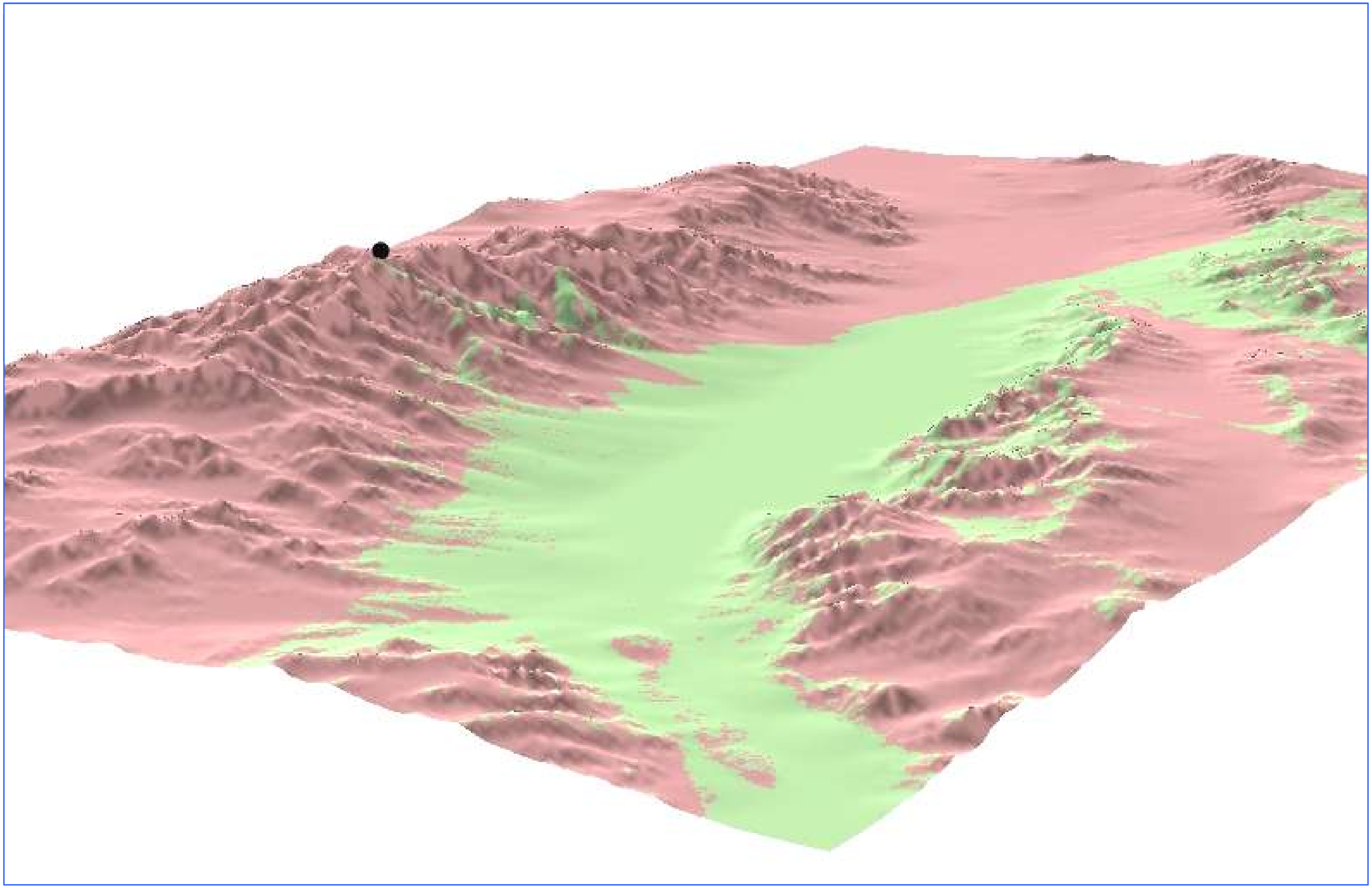
Introduction

- Digital terrain modelling witnessed ‘revolution’ in recent years with development of high resolution remotely sensed data (e.g. radar and lidar).
- Traditional Digital Elevation Models (DEMs) are bare-earth DTMs (Digital Terrain Models). Digital Surface Models (DSMs) include additional surface information (e.g. buildings, roads and vegetation)
- Visibility analysis (intervisibility analysis, viewshed analysis) is one of the most popular application areas for DEMs
- Virtually all visibility/viewshed analysis has been performed with bare-earth DEMs. Lack of topographic features means viewsheds are very erroneous as a result.
- Very little verification work done on relative accuracy of DEMs for visibility analysis, (Maloy & Dean, 2001; Kidner et al, 2001)

Viewshed Overview



Objective of Research

- Evaluate latest-generation DSMs and conventional bare-earth DTMs for visibility analysis performance.
- Attempt to quantify differences in Line-of-Sight accuracy between the DEMs.
- Highlight some considerations for the transition from digital terrain modelling to digital surface modelling

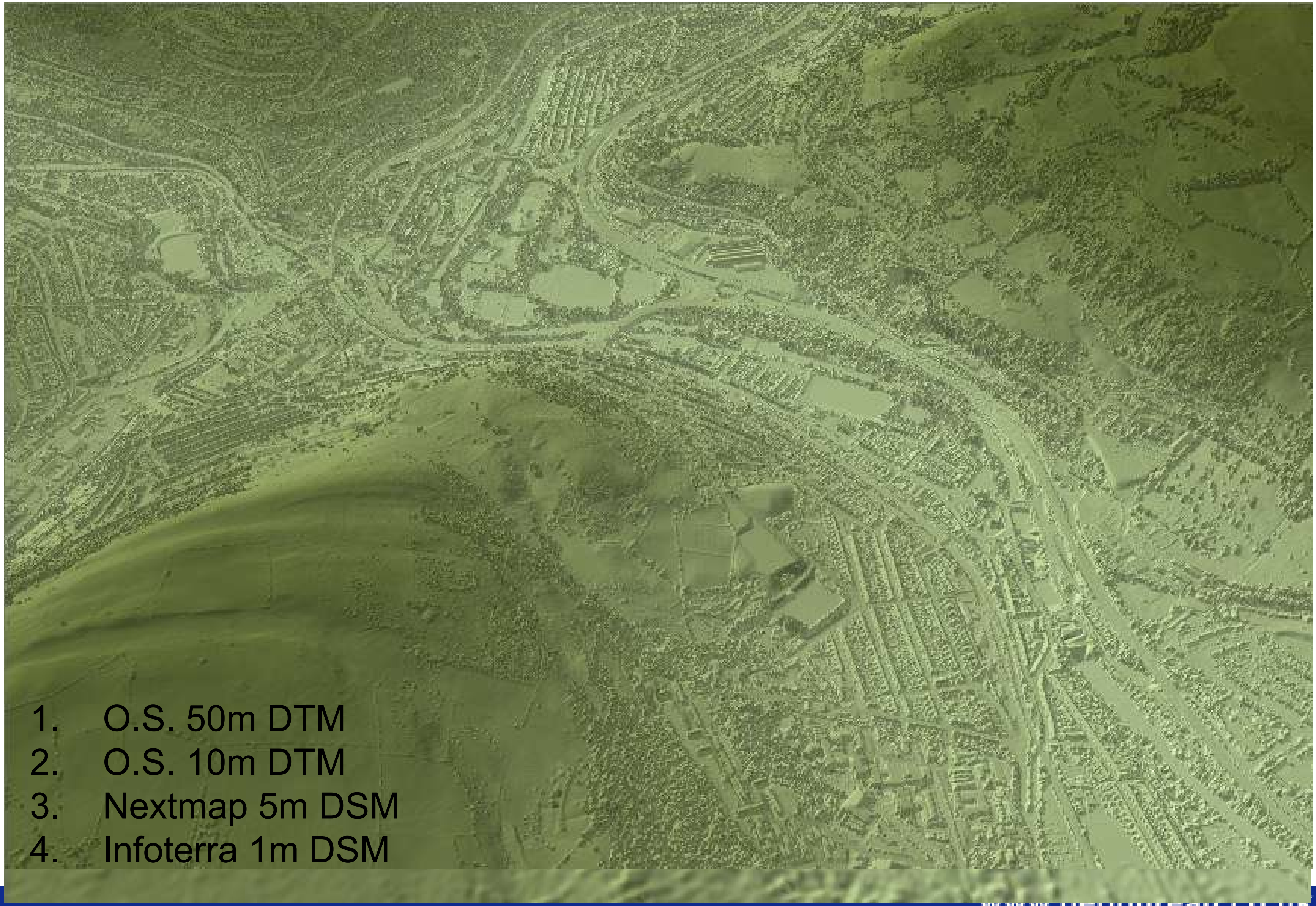
Commercial grid data evaluated:

- Digital Surface Models (DSMs)
  - Lidar First Pulse Return (Infoterra) 1m (www.infoterra-global.com/lidar_air.htm)
  - Lidar Last Pulse Return (Infoterra) 1m
  - NextMap Britain IFSAR 5m (http://www.intermap.com/corporate/greatBrit.cfm)
- Bare Earth Digital Terrain Models (DTMs)
  - Lidar Last Pulse Return 1m
  - NextMap Britain 5m
  - Ordnance Survey Landform Profile 10m (www.ordnancesurvey.co.uk)
  - LandMap IFSAR 25m (www.landmap.ac.uk/products/dem.html)
  - Ordnance Survey Landform Panorama 50m

Data Summary

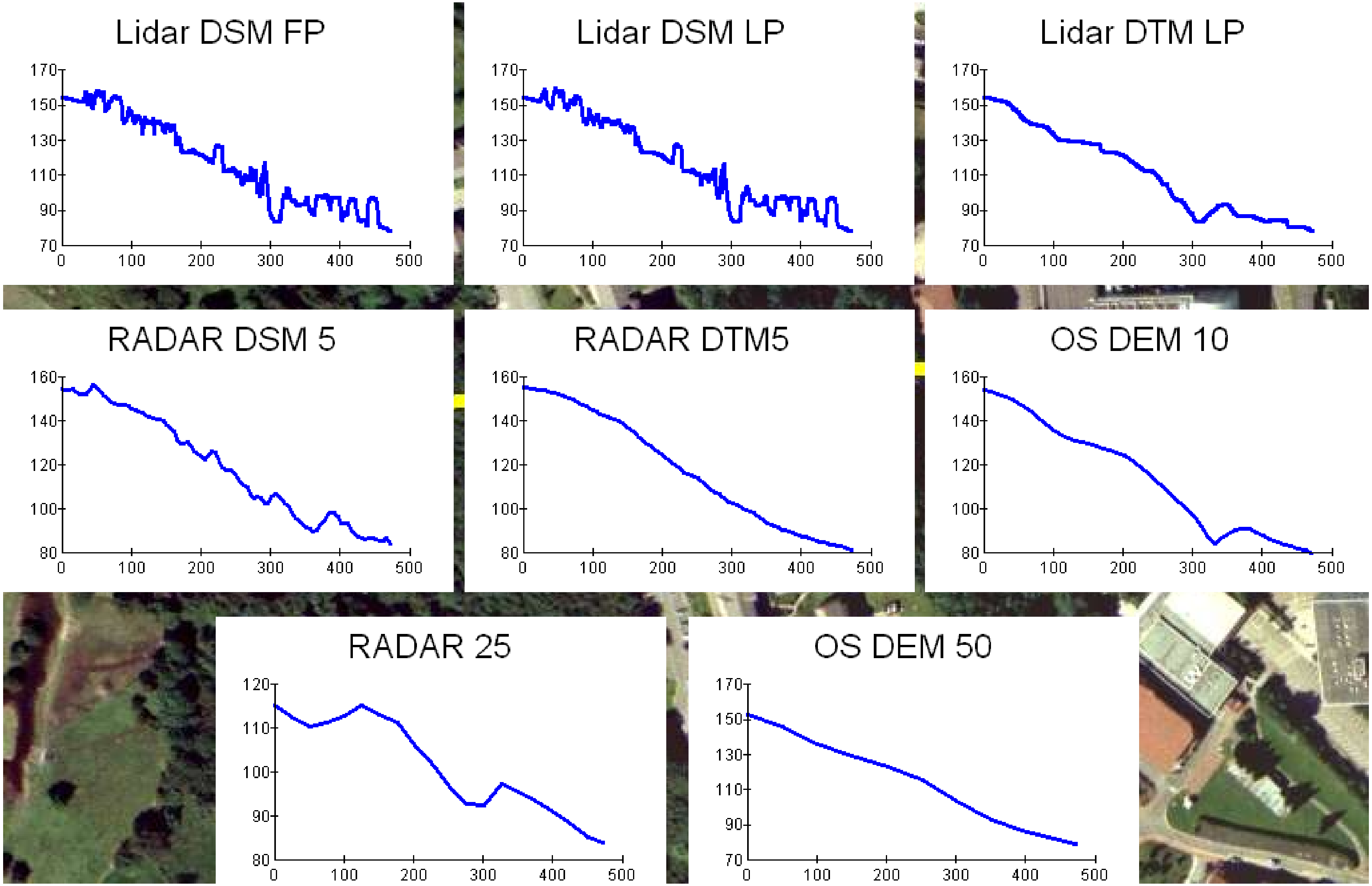
Product	Horizontal Resolution	Vertical Accuracy (m)	Price
Lidar DSM first pulse return	1	0.25	£150 per km^2
Lidar DSM last pulse return	1	0.25	£150 per km^2
Lidar DTM last pulse return	1	0.25	£150 per km^2
NextMap IFSAR DSM	5	1-1.5	£1.75-£12.00 per km^2
NextMap IFSAR DTM	5	1-1.5	£1.75-£12.00 per km^2
Satellite IFSAR (LandMap)	25	5-30	FOC - education
OS Landform Profile	10	3	Entire Wales coverage £537 p.a.
OS Landform Panorama	50	5	iscontinued – education only

DEM Comparisons

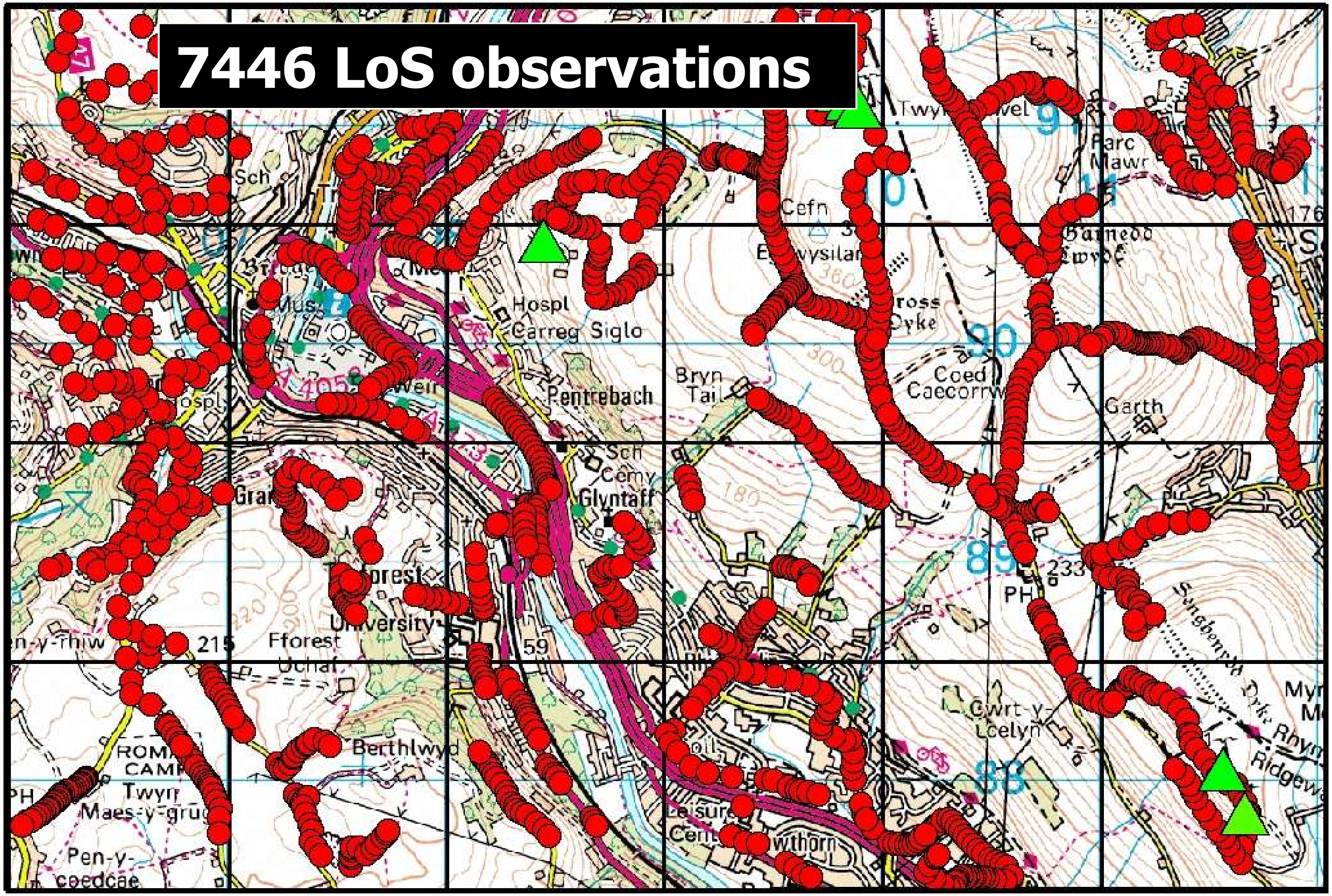


1. O.S. 50m DTM
2. O.S. 10m DTM
3. Nextmap 5m DSM
4. Infoterra 1m DSM

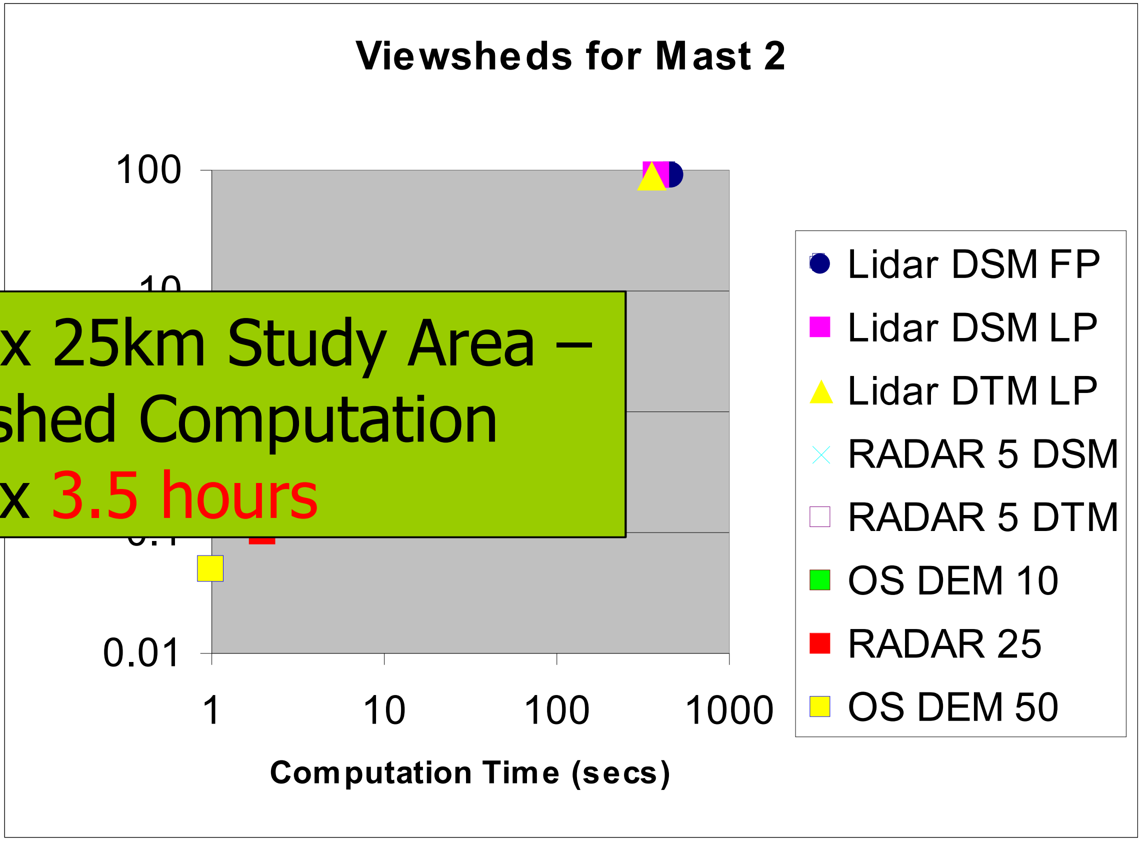
DEM Comparisons



Methodology



Computing the Viewsheds

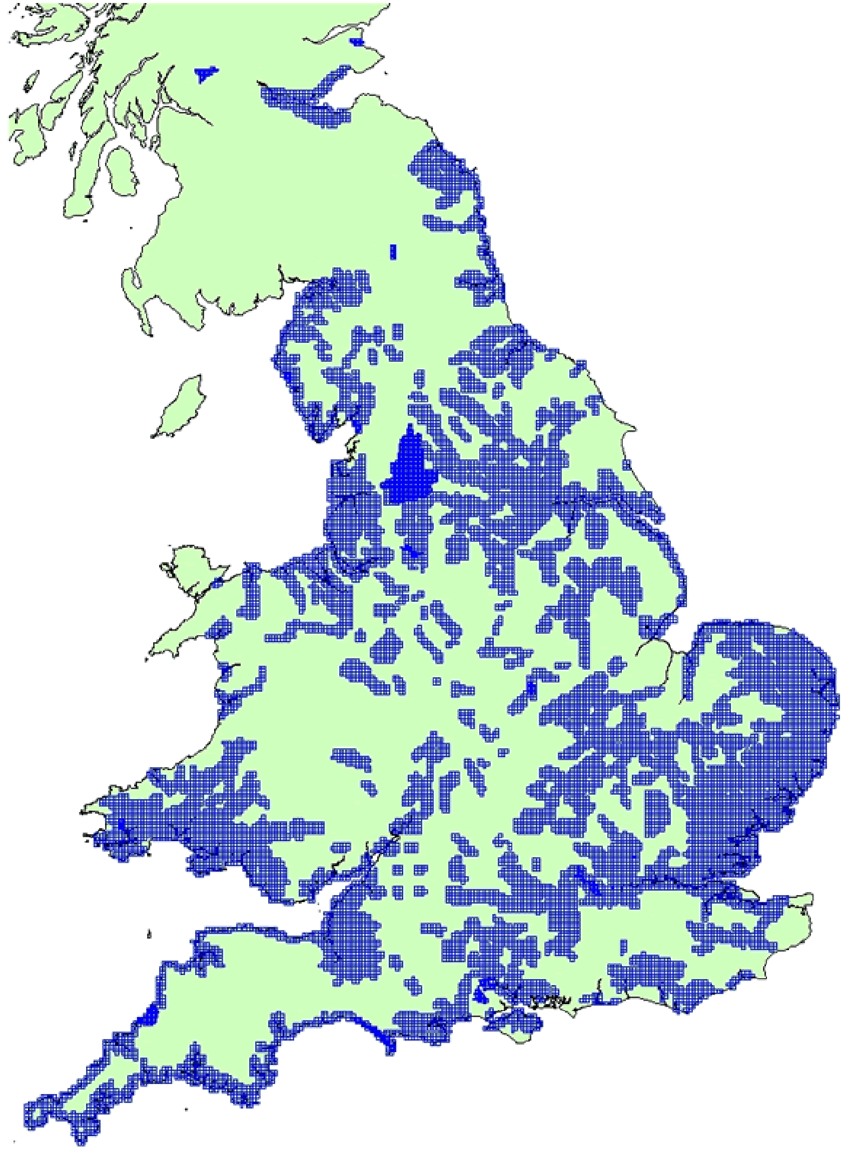


Typical 25 x 25km Study Area – Lidar Viewshed Computation time approx 3.5 hours

	Lidar DSM FP	Lidar DSM LP	Lidar DTM LP	RADAR 5 DSM	RADAR 5 DTM	OS DEM 10	RADAR 25	OS DEM 50
Compuation Time (Secs)	471	386	361	15	15	4	2	1
File Size (Mb)	92	92	92	3.73	3.73	0.98	0.1	0.05

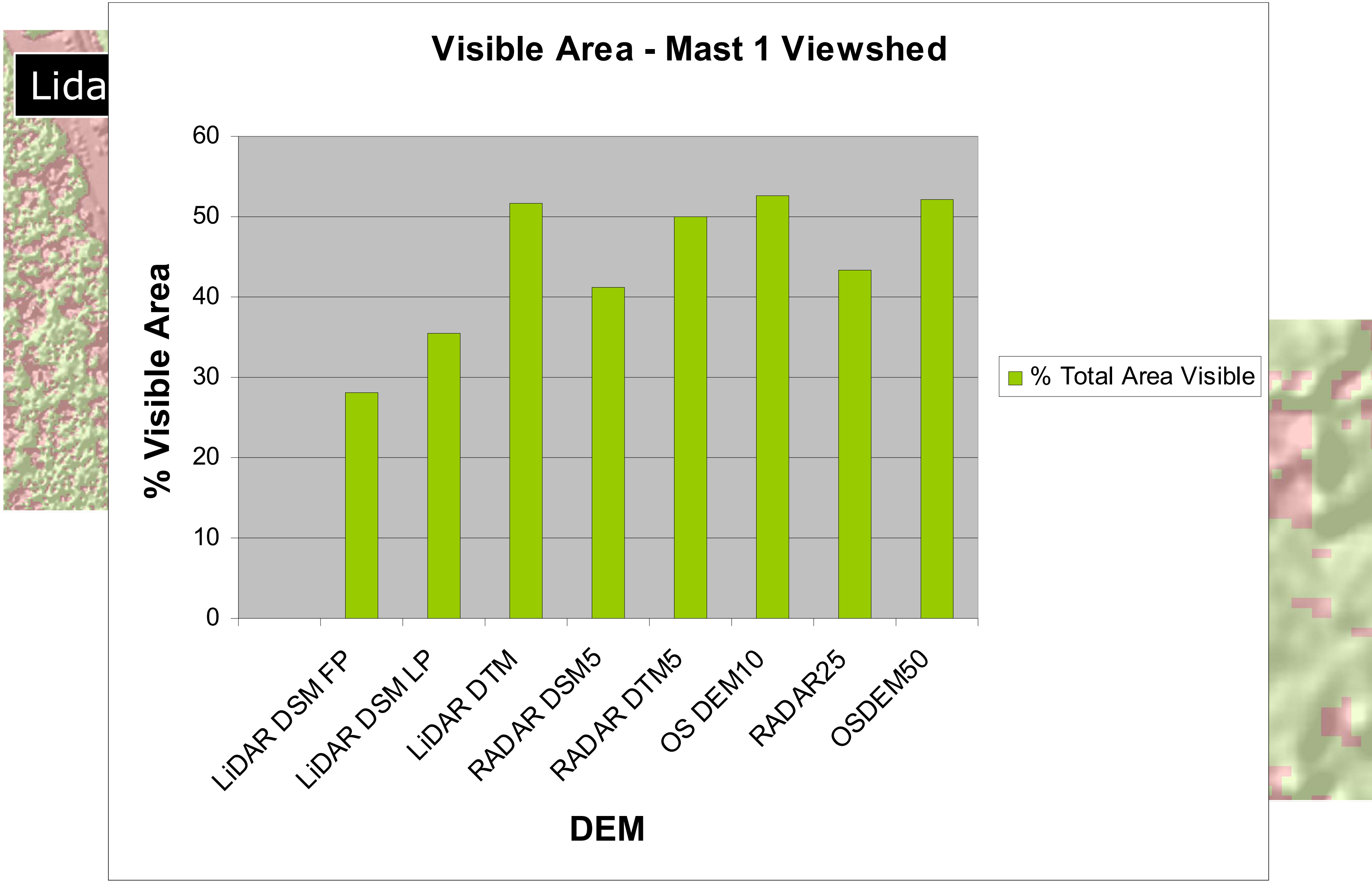
UK Lidar Coverage

(Environment Agency, 2005)



http://www.environment-agency.gov.uk/commondata/103196/219863

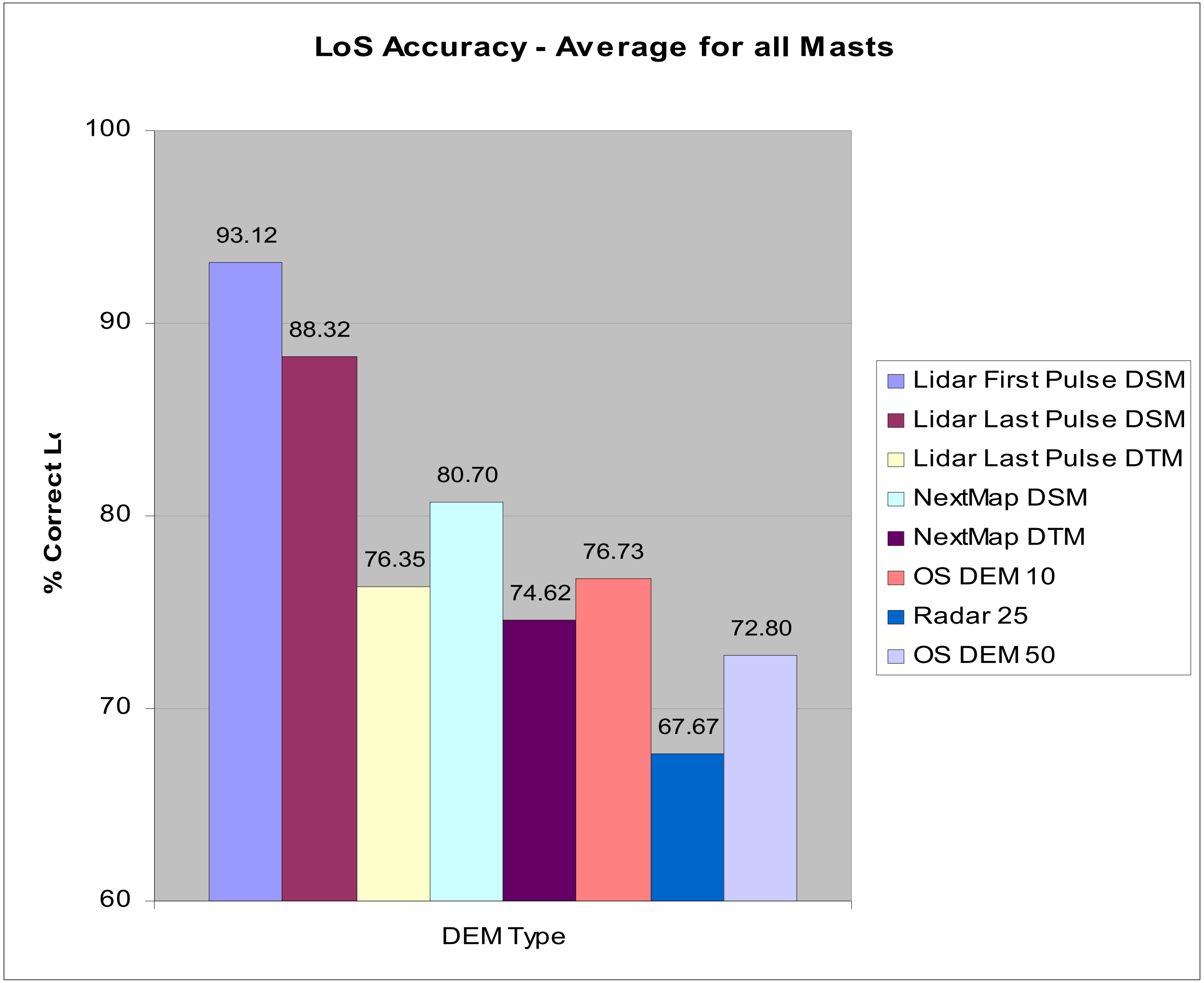
Viewshed Variation



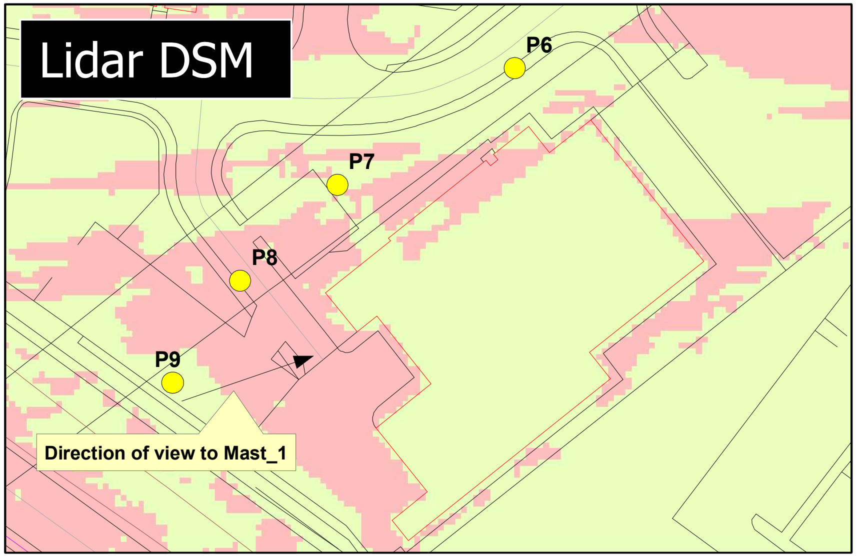
Results – Viewshed Accuracy (1)

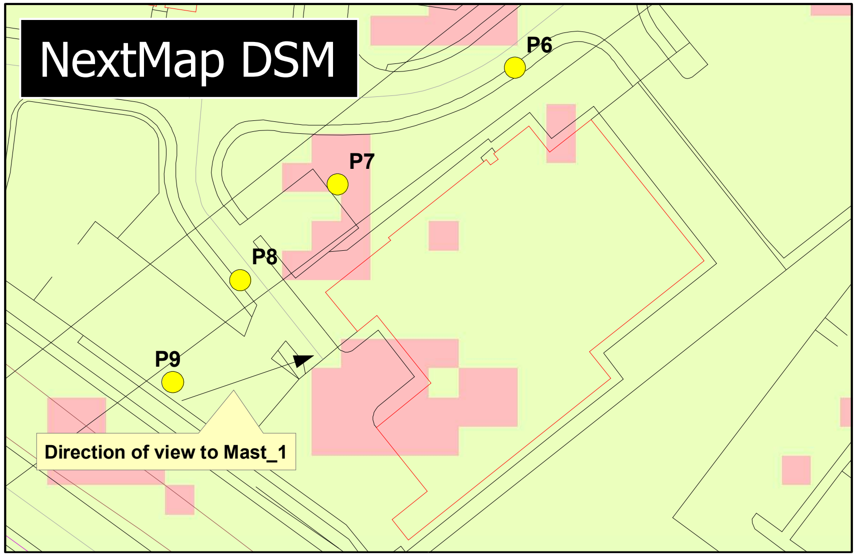
DEM Type	Mast 1	Mast 2	Mast 3	Mast 4	Mast 5	Mast 6
Lidar First Pulse DSM	**92.26**	**91.78**	**95.49**	**94.28**	**92.43**	**92.51**
Lidar Last Pulse DSM	85.98	85.58	87.43	91.22	90.25	89.44
Lidar Last Pulse DTM	75.66	71.96	74.46	80.10	78.00	77.92
NextMap DSM	78.65	76.95	79.13	84.85	82.76	81.87
NextMap DTM	74.94	70.99	71.72	78.16	76.31	75.58
OS DEM 10	75.58	71.80	74.38	80.74	79.53	78.32
Radar 25	67.53	65.83	73.41	67.69	65.67	65.91
OS DEM 50	70.83	67.45	70.43	78.00	74.86	5.26

Results – Viewshed Accuracy (2)

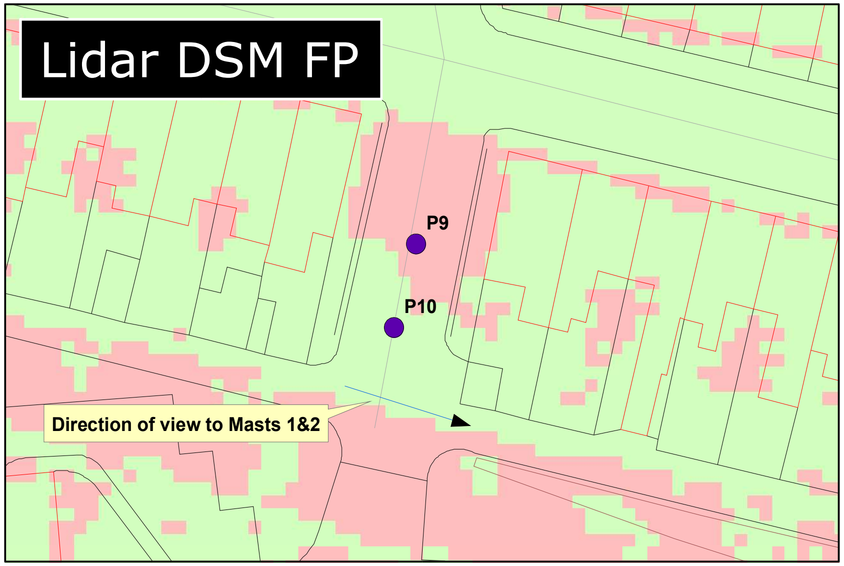


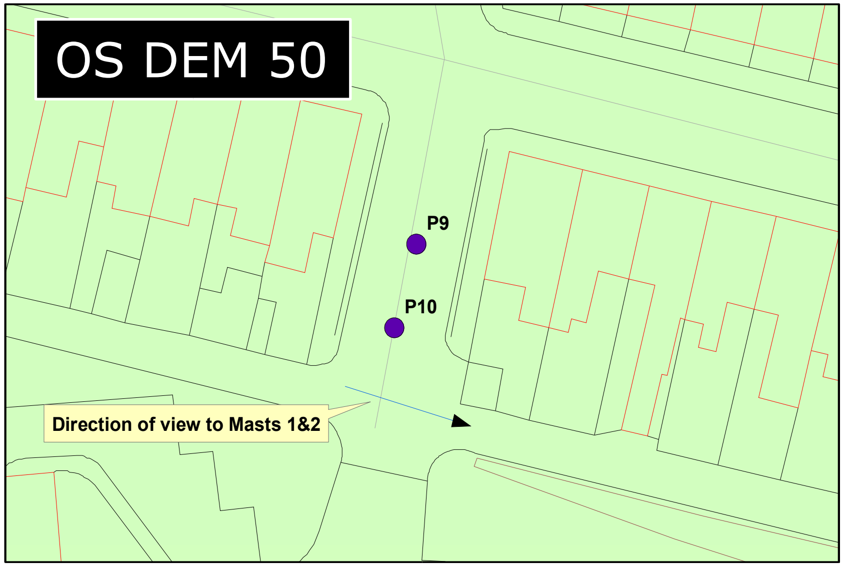
Viewshed Accuracy - Example 1



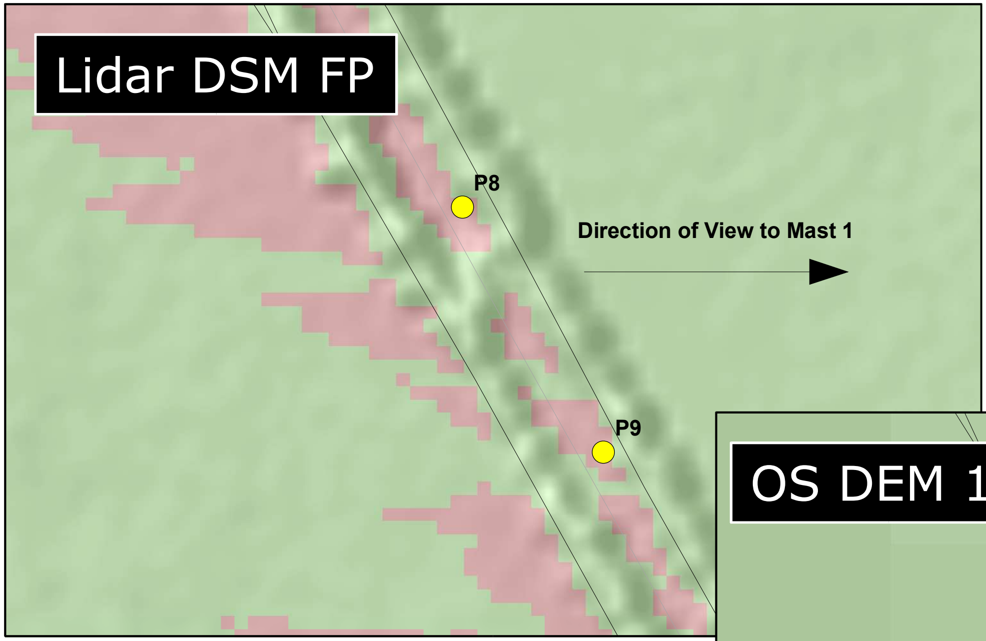


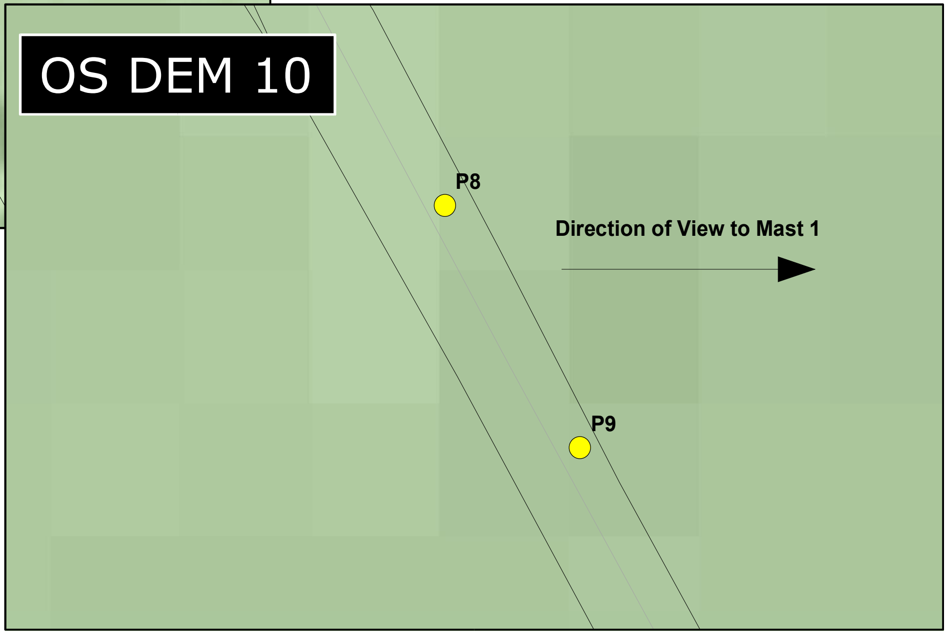
Viewshed Accuracy Example 2



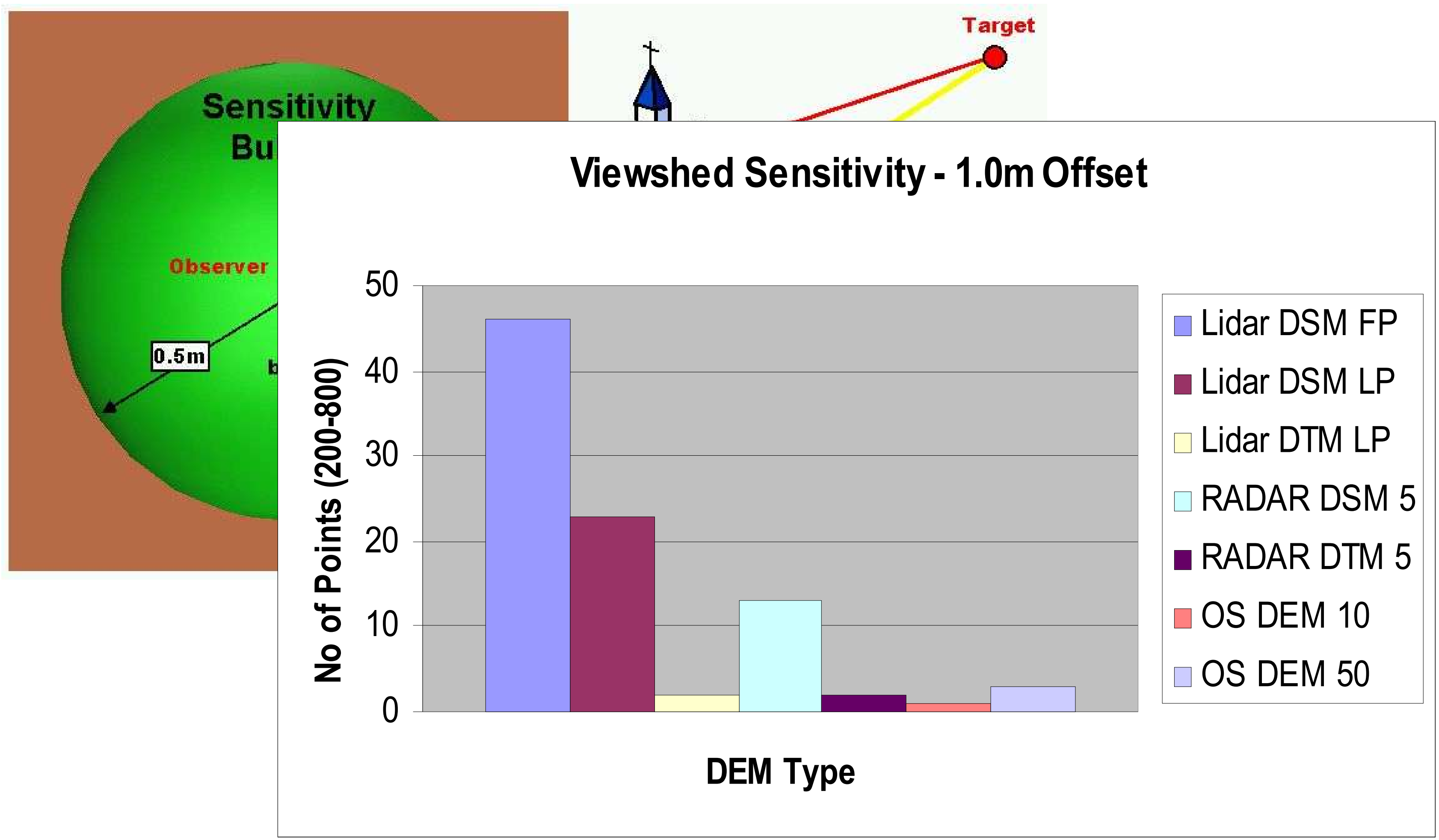


Viewshed Accuracy Example 3





Viewshed Sensitivity



Conclusions

- Lidar DSM produces the most accurate viewsheds but has has drawbacks; cost, computation time, data storage, coverage.
- Lidar viewshed - Is this level of accuracy really desired? E.g. Regional visibility analysis for wind farm planning application.
- DTMs significantly overestimate visibility
- Reconsideration of viewshed computed using DSMs. High-resolution bare-earth DTM + topographic layers may be more suitable.
- Binary viewshed too simplistic, especially in high resolution DSMs.

Further Work

- Further work on probable viewsheds by expanding on the sensitivity analysis.
- Investigate the relationship between DEM error and viewshed accuracy over the study area.
- Include additional elevation data models for evaluation. E.g. TIN models and bare-earth DTM with added building and vegetation layers.
- Evaluate range of viewshed algorithm implementations
- Analyse accuracy of models by land use type – e.g. urban and rural using remotely sensed imagery.