Irish Quaternary Association Annual Symposium 2012

Programme and Abstracts

Remote sensing: Applications in Quaternary science, archaeology and landscape management

Friday 30th November 2012

Geological Survey of Ireland, Beggar's Bush, Dublin 4

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Remote sensing: Applications in Quaternary science, archaeology and landscape management

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Cover image: 3D view of lidar data, Brú na Bóinne WHS, looking approximately northeast towards Newgrange and Dowth (Dr Stephen Davis, UCD).

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IQUA Annual Symposium 2012 Programme

9:30 – 10:00 Registration/coffee
10:00 – 10:10 Welcome

Keynote Speaker
10:10 – 10:55 **Professor Michael Doneus (Ludwig Boltzmann Institute, Vienna)**: *Advancing the documentation of buried and submerged archaeological landscapes*

10:55 – 11:20 **Anthony Corns (Discovery Programme)**:
Arriving at the same point: Method and technologies for the 3D modelling of landscapes

11:20 – 11:45 **Coffee**

11:45 – 12:10 **Kevin Barton (LGS Ltd.)**:
Geophysical imaging in geological and archaeological investigations in some Irish wetland environments

12:10 – 12:35 **Dr Paul Gibson and Dr Xavier Pellicer (NUI Maynooth)**:
Investigation of Quaternary sediments using 2D time-lapse electrical resistivity tomography

12:35 – 13:50 **Lunch**

13:50 – 14:15 **Ray Scanlon[1], James Hodgson[1], Mohammednur Desissa[2], Mairead Glennon[1], Kate Knights[1] and Shane Carey[1] ([1]Geological Survey of Ireland; [2]Geological Survey of Northern Ireland)**
The Tellus Border Project: Regional geo-environmental mapping through airborne geophysics and geochemistry sampling

14:15 – 14:40 **Dr Robbie Meehan (GSI/Talamhireland)**:
Irish Quaternary Geological Mapping: Sediments and Geomorphology

14:40 – 15:05 **Dr Ruth Plets (University of Ulster, Coleraine)**:
Keeping our feet dry: marine geophysical tools for the study of underwater archaeology and Quaternary research

15.05 – 15.40 **Coffee**

15:40 – 16:05 **Keith Challis:**
Beyond Red: Applications of Multispectral Remote Sensing in Geoarchaeology

16:05 – 16:30 **Conor Galvin (Office of Public Works)**:
Applications of Remote Sensing in Flood Risk Assessment in Ireland

16:30 – 17:00 **Discussion**

The discussion will be followed by a reception in honour of Frank Mitchell's centenary

Keynote presentation:

Advancing the documentation of buried and submerged archaeological landscapes

Professor Michael Doneus

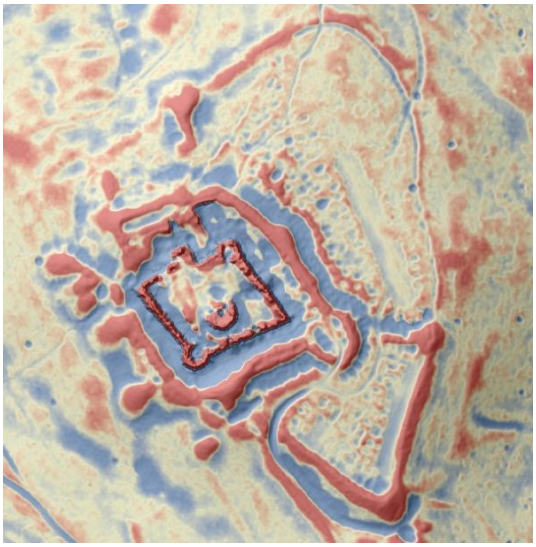
Deputy Director of the Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology
Email: Michael.Doneus@archpro.lbg.ac.at

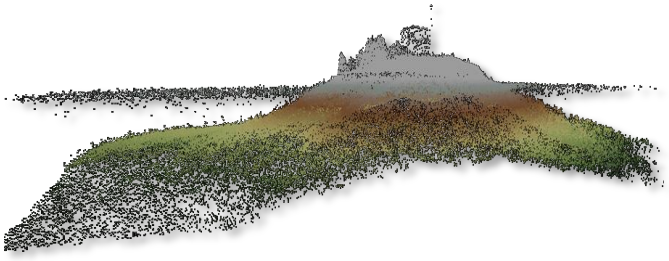
Over the past decades landscape archaeology has increasingly gained importance. Despite a large variety of different approaches, a tacit agreement consists in the fact that landscape archaeologists are investigating beyond the individual site, dealing with space at different scales. This has led many archaeologists as well as preservationists to enlarge their field of endeavour from sites towards archaeological landscapes.

In order to be able to protect archaeological landscapes, these have to be identified and documented, using fast, efficient and reliable prospection methods that can cover large areas. Also, archaeological prospection is usually defined as tools and methods to gain knowledge on archaeological sites before or instead an archaeological excavation. However, this does not fully apply to the potential of archaeological prospection, which can also reveal important information on palaeoenvironmental structures, especially from the Quaternary. To do so, archaeological prospection has to be applied mainly on a large-scaled basis.

Therefore, large-scale application of non-invasive archaeological prospection methods (e.g. aerial archaeology, airborne laser scanning and high-resolution near-surface geophysical prospection) offer a great potential. They are the most appropriate solution in order to provide both landscape archaeologists and planning authorities with the necessary spatial information at multiple scales, ranging from the archaeological site to the entire archaeological landscape.

The presentation will therefore focus on a wide range of prospection methods that can be applied on a landscape scale in a variety of environments. It will demonstrate the latest developments in aerial archaeology, airborne laser scanning, airborne imaging spectroscopy, but also geophysical methods (mainly magnetics and ground penetrating radar). It will finally discuss the possibilities and limitations of bathymetric sensor technique in the attempt to overcome the border between land and water.





Arriving at the same point: Method and technologies for the 3D modelling of landscapes

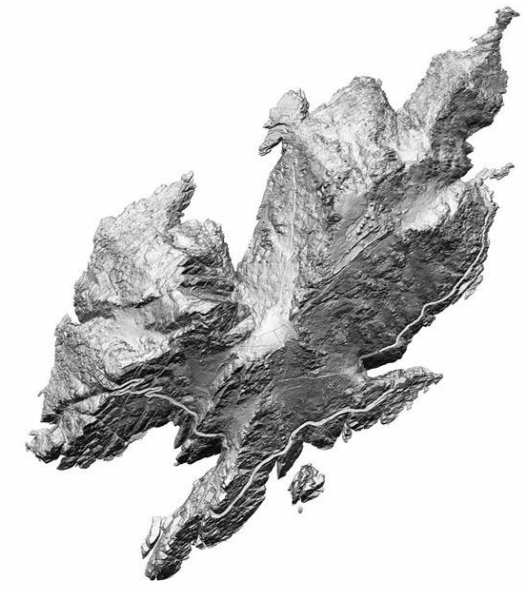
Anthony Corns

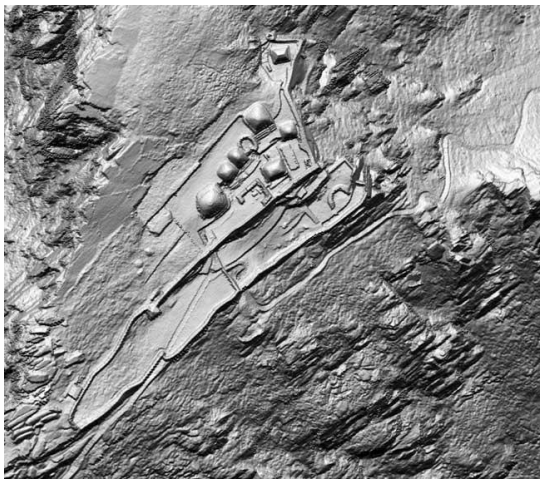
The Discovery Programme, Merrion Square, Ireland.

anthony@discoveryprogramme.ie

Since 1996 the Discovery Programme has been at the forefront of applied research in the recording and modelling of archaeological landscapes and monuments using a range of remote sensing techniques and methods. The application of remote sensing techniques within archaeology and cultural heritage has enabled the rapid and accurate recording of a range of monuments from the earthen structures of Tara to the extreme topographic features of Skellig Michael, revealing new archaeological features or recording areas where conventional survey would be impossible.

This presentation will highlight a selection of remote sensing examples from Ireland which range in both scale and topographic character. It will discuss the benefits and costs of a range of approaches including lidar, photogrammetry and terrestrial laser scanning and explore how the results of these surveys have increased our understanding and management of archaeological sites and landscapes. Finally it will discuss how the combination of several remote sensing techniques and applications can provide a powerful toolkit in the non-destructive analysis of the past and enable a more qualified approach to the investigation of subsurface features.





Geophysical imaging in geological and archaeological investigations in some Irish wetland environments

Kevin Barton

Landscape and Geophysical Serviced Ltd., Claremorris, Co. Mayo.

eolas@lgs.ie

Wetlands are composed of many shapes, sizes, sediment types, vegetation and, in particular for the practical aspect of geophysical surveying, have varying degrees and types of water saturation. These environments present many challenges in geophysical investigations both in field surveys and interpretation. Wetland environments often do not have a depth of water suitable for use of a boat as a survey platform. Field conditions with unpredictable, soft, yielding ground make for difficulties in carrying out systematic area surveys often required in geological and archaeological investigations. The survey area may be not stable enough to walk on or drive on using hand-carried or towed survey instruments. In addition potential geological and archaeological targets have to have a sufficient size or volume combined with a detectable physical property contrast with the host or background sediment. If the particular field conditions are suitable and the target and survey area has geophysical potential the next step is to assess the measurements that need to be made and the method of deployment of suitable instruments.

It is therefore in the combination of field conditions, target type and size, possible contrasts with host sediments, appropriate geophysical technique and mode of instrument deployment where the challenge lies in specifying and successfully carrying out a geophysical survey in a wetland environment. In blanket bog and tidal wetlands the Electrical Resistivity Tomography (ERT) technique has been successful in geological and archaeological investigations.

This presentation will discuss the ERT technique in the experimental mapping of the sub-peat extent of Glenulra Court Tomb in the blanket bog of Céide Fields, Co. Mayo. Here cutaway bog with variable topography and saturation prevented the use of conventional geophysical techniques used in archaeological investigations. The utility of the ERT technique will be shown through its use in a geo-archaeological investigation of the Woodstown tidal wetland, Co. Waterford. Here ERT was used to map a tidal embayment of the River Suir to assist in the location of coring sites crucial to a palaeoenvironmental reconstruction of the wetland adjacent to the Viking Age Woodstown 6 site.

Acknowledgement

The Woodstown project was funded by the National Roads Authority and Waterford City Council.

References

Barton, K. *Forthcoming*. Resistivity profiling. Appendix 2.1 in I. Russell and M.F. Hurley (eds.) *Woodstown: A Viking Age Settlement in County Waterford.*

Coxon, P. and Farrell, A. *Forthcoming.* Sedimentological and palaeoenvironmental investigations. Section 2.2 in I. Russell and M.F. Hurley (eds.) *Woodstown: A Viking Age Settlement in County Waterford.*

Investigation of Quaternary sediments using 2D time-lapse electrical resistivity tomography

Paul Gibson[1] and Xavier Pellicer[2]

[1] Environmental Geophysics Unit, Dept. of Geography, NUI, Maynooth
[2] Geological Survey of Ireland

Electrical Resistivity Tomography (ERT) data can provide detailed subsurface information and they are influenced by a number of factors associated with the subsurface such as porosity, moisture content and lithology; as well as external factors such as rainfall and temperature. Little work has been carried out in Ireland on the additional information that can be obtained from time-lapse ERT. Two experiments were conducted to determine how resistivity varied with time. One short experiment was controlled and provided very detailed information about shallow temporal variations in resistivity as a result of a point source 'pollution' event. Initial changes were mainly confined to the top 25cm and the wetting front moved at a rate of about 1m per hour. The second experiment was considerably larger both spatially and temporally. In this instance, two time-lapse ERT profiles with 5m and two with 2m electrode spacings were acquired over a range of Quaternary sediment types encompassing till, esker gravel, glaciofluvial sand and silt and glacio-lacustrine silt/clay. Data were collected for these four lines on the same day on a monthly basis for a year at a site located in the Irish midlands, see example in Figure 1.

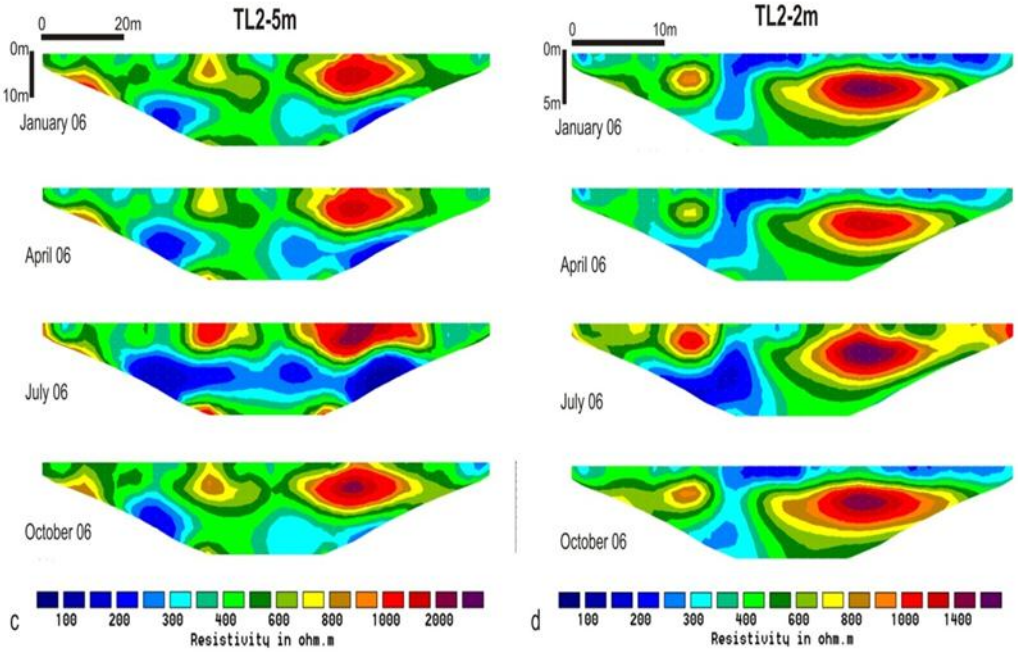


Figure 1: Resistivity traverses in Irish Midllands.

Effective recharge, the depth of investigation, the texture and the internal architecture of the different sediment types and temperature variation are the main factors influencing the resistivity seasonal variation. The shallow subsurface (<3m depth) showed a direct relationship between resistivity variation and effective recharge, whereas, an increasing time-lag between effective recharge and resistivity was recorded at increasing depths. As a result of the time-lag, it was possible to determine the rate of movement of the wetting/drying front for the unconsolidated relatively sorted coarse sediments at 7.8 cm/day. Conversely, poorly sorted and fine sediments show little resistivity variation and the velocity of the wetting front could not be estimated. Other factors influencing the electrical response of the subsurface are the electrode spacing used for data collection and the seasonal temperature variation of the subsurface. Two methods for temperature correction of electrical resistivity data were tested in this study — both gave similar results. Resistivity values recorded in the shallow subsurface (<5 m) show variations of over 15% due to temperature variation.

The Tellus Border Project: Regional geo-environmental mapping through airborne geophysics and geochemistry sampling

Ray Scanlon[1], James Hodgson[1], Mohammednur Desissa[2], Mairead Glennon[1], Kate Knights[1] and Shane Carey[1]

Geological Survey of Ireland, Beggar's Bush, Dublin 4

Ray.Scanlon@gsi.ie

[1]Geological Survey of Ireland, [2]Geological Survey of Northern Ireland

ray.scanlon@gsi.ie

Tellus Border is an EU INTERREG IVA-funded regional project which will map the environment of the six border counties of the Republic of Ireland- Donegal, Sligo, Leitrim, Cavan, Monaghan and Louth - through airborne geophysical and ground-based geochemical surveys. This joint initiative between the Geological Survey of Ireland, the Geological Survey of Northern Ireland, Dundalk Institute of Technology and Queens University Belfast follows on from the successful Tellus project which was recently completed in Northern Ireland. The work will provide scientific data which will inform environmental management and support sustainable development of our natural resources, including agricultural soils, groundwater and energy resources in the border region. Research projects based in Queens University Belfast will investigate the application of the airborne geophysics to the assessment of groundwater pollution plumes and peat depth.

Both geochemical and airborne geophysical components surveys were successfully completed during the summer of 2012.

The airborne geophysics survey operated as a low-level survey, measuring magnetic field, gamma-ray spectrometry and electrical conductivity along lines spaced 200m apart and in flight direction 345 degrees across the border region. The Geochemical survey entailed the collection of approximately 3500 samples each of soils, stream sediments, stream water and vegetation. The samples are currently being analysed in a laboratory for a range of chemical elements and compounds.

Following final data quality assessments, the data will be merged with existing surveys to provide a seamless dataset across the region allowing detailed interpretations. Final merged magnetic and gamma-ray spectrometry data will be available to the public following the launch of the data in earlyFebruary 2013. The electrical conductivity data and results from the geochemistry programme will be available later on in 2013.

A Tellus Border research opportunity was announced in 2012 and researchers from all sectors will shortly be invited under several research themes to tender for funding. This call presents opportunities for interdisciplinary research using the world-class geochemical and airborne geophysics data newly acquired as part of Tellus Border and existing Tellus data from Northern Ireland.

Irish Quaternary Geological Mapping: Sediments and Geomorphology

Dr Robbie Meehan

GSI/Talamhireland

antalamhireland@gmail.com

The Quaternary Section of GSI recently began a National Quaternary Map project. The project involves the integration of all previously mapped GSI Quaternary field data, Teagasc subsoil data and GSI subsoil permeability data, as well as available information from consultant's reports, academic papers and theses, and mapping projects, into a GIS. The integration of these data involves their re-interpretation into a consistent, seamless, national Quaternary classification scheme. This schema will facilitate compliance with INSPIRE terminology and fields.

The construction of the 'Map' coverage involves developing four separate ArcGIS geodatabase layers including; Quaternary geomorphology; Quaternary sediment type; depth-to-bedrock; and depth-of-sediment strata. These geodatabases will host several individual shapefiles and all will have up-to-date metadata constructed for them. The geodatabase coverage will be displayed on a backdrop of renditions of slope and elevation-shaded Digital Elevation Model data for Ireland, captured across a 10 m grid.

On completion of the project in 2013 a web viewer incorporating the four map layers, with print, download, WMS and other functionality will be made available on www.gsi.ie. The presentation will focus on the recently-completed pilot study for County Mayo, which covers almost 10% of the country. The geomorphological maps have uses in ice sheet modelling, morphological mapping and for educational and geodiversity purposes The sediment, depth to bedrock and depth of sediment strata layers underpin applications in; geotechnics, environmental protection, aggregate potential mapping, geohazard mapping, soil modelling and Geological heritage.

Keeping our feet dry: marine geophysical tools for the study of underwater archaeology and Quaternary research

Dr Ruth Plets

University of Ulster, Coleraine

r.plets@ulster.ac.uk

The development of acoustical oceanography took off after the sinking of the Titanic in 1912 and was significantly improved as a detection technique during World War I. Since then, these acoustic techniques have evolved from detection (e.g. icebergs, submarines) to full exploration tools (e.g. the hydrocarbon industry). Furthermore, rapidly evolving computer processing and digital recording in the last few decades have allowed the detection and imaging of geological, geomorphological and archaeological features lying on or buried within the seabed, down to the sub-metre scale.

Marine remote sensing techniques can be divided into two broad categories: techniques that (1) image the seafloor and objects laying on it or (2) image the sub-surface stratigraphy and objects buried within the sediments. Currently, the most commonly used instruments for archaeological and Quaternary research that fall within these categories are (1) multibeam echosounders and side-scan sonars, and (2) high resolution sub-bottom profilers. A more recently available non-acoustic remote sensing technique is bathymetric LiDAR (Light Detecting And Ranging), which has proven to work in very shallow waters.

On the island of Ireland, the scientific community has been blessed by readily available high quality marine geophysical data which can be used by a multitude of disciplines. Notable projects collecting such data include the INSS/INFOMAR (Irish National Seabed Survey / Integrated Mapping for the Sustainable Development of Ireland's Marine Resource) and JIBS (Joint Irish Bathymetric Survey). The data collected by these projects over the past decade have allowed an unparalled view of the Irish seabed, which in turn affords a unique opportunity to study the natural and cultural history hidden beneath the water.

With respect to archaeology, these techniques have not only allowed us to detect shipwrecks, but also to study the wider environment in which such sites are situated and associated site formation processes, an important issue from a management perspective. A growing maritime archaeological discipline is the study of submerged landscapes: former terrestrial landscapes on which humans could have lived, but which have been inundated by postglacial sea-level rise. Such studies are closely linked to Quaternary research examining the extent and origin of ice sheets and the changing position of relative sea-level over the past 2.6Ma (but concentrating on the last c.24,000 yrs). Currently, signatures found on or within the seabed are often ignored, although they could provide important clues about former oceanic conditions around Ireland and potential migration routes for humans and animals.

This talk will illustrate some of the work that has been undertaken by archaeologists, geologists and geomorphologists from the University of Ulster using remote sensing techniques to investigate the wealth of information hidden beneath the waves.

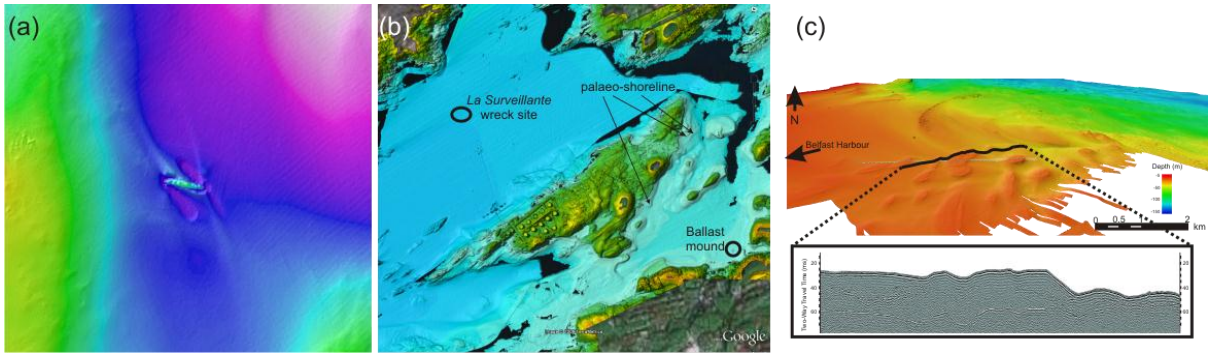


Figure 1. Examples of marine geophysical data showing (a) a shipwreck with associated scour, (b) seamless LiDAR and bathymetric data (Bantry Bay) and (c) bathymetric and sub-bottom data over a planed-off submerged drumlin field.

Beyond Red: Applications of Multispectral Remote Sensing in Geoarchaeology

Keith Challis

k.challis@bham.ac.uk

Multispectral remote sensing offers considerable advantages over conventional aerial imaging for the detection and mapping of geoarchaeological features. In particular the enhanced ability to distinguish slight variations in soil and vegetation properties in the infrared part of the spectrum greatly amplifies the visibility of ephemeral anthropogenic features and evidence for terrace and floodplain architecture in fluvial zones. Drawing on examples from river valleys and uplands in the UK this paper considers the principals, techniques and results of multispectral remote sensing, using both airborne and satellite sensors, for geoarchaeological prospection and mapping.

Applications of Remote Sensing in Flood Risk Assessment in Ireland

Conor Galvin

Office of Public Works

conor.galvin@opw.ie

The Office of Public Works (OPW) is the lead agency for flood risk management in Ireland. In this role, the OPW is undertaking a nationwide Catchment Flood Risk Assessment and Management (CFRAM) Programme. The purpose of this programme is to identify and map the existing and potential future flood risk areas and to develop Catchment Flood Risk Management Plans to address the identified risk.

The three main outputs of the CFRAM Programme are: Preliminary Flood Risk Assessment, Flood Hazard Mapping and the development of Catchment Flood Risk Management Plans. The first two of these outputs are heavily reliant on remotely sensed data.

Preliminary Flood Risk Assessments (PRFA)

The first step in the CFRAM programme was to identify areas where there is a potential significant flood risk. Flood Risk is a combination of Flood Hazard and the vulnerability of Flood Receptors. Flood Hazard areas are the predicted extents of flood inundation. Flood Receptors datasets are used to reflect the impact that flooding has on human health, the environment, cultural heritage and economic activity.

Flood hazards are mapped by combining hydrological and hydraulic data with topographical information. In the case of the PFRA, the hydrological analysis (or estimation of flows at points down through the river network) was informed by remotely sensed datasets describing the river catchments, such as land-use, soil types, topographical characteristics and the structure of the river network. The topographical information used was a Digital Terrain Model (DTM) produced by Intermap from Interferometric Synthetic Aperture Radar (IFSAR) data captured in the autumn of 2007. The DTM has a vertical accuracy of 0.7m (RMSE).

Catchment Flood Risk Assessment and Management Studies

Based on the outputs of the PFRA the OPW has commissioned CFRAM studies to further maps and assess areas of significant risk and to produce Flood Risk Management Plans. To facilitate this the OPW have procured over 7,000 km^2 of lidar data in areas of significant risk. This lidar data has a vertical accuracy of 0.02m (RMSE).

This data is input to hydrodynamic models, in combination with river and bathymetric survey data and derived hydrological information, which are then integrated with DTMs of the surrounding floodplains to produce predictive flood extents. The resulting flood risk can then be quantified, by combing these flood extents with receptor data, many of which themselves are derived and mapped using remote sensing techniques..

Application of Remotely Sensed Data

This presentation will detail how remotely sensed data is used to derive the predicted Flood Hazard at the PFRA and CFRAM stages and to determine where this flood hazard interacts with Flood Receptors.

NOTES