Department of Enterprise, Trade and Investment
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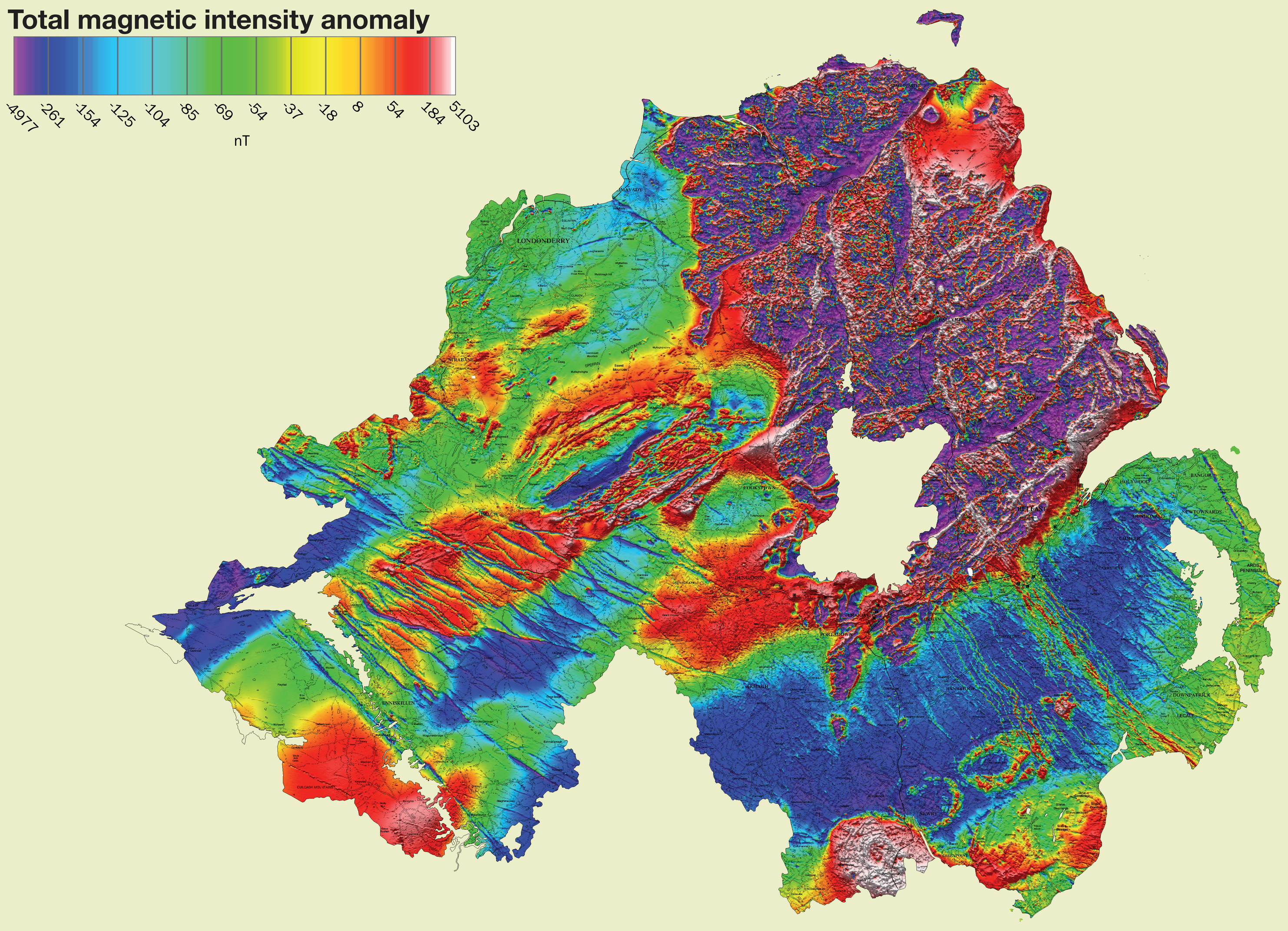
Geological Survey of Northern Ireland

Airborne geophysical mapping of environmental features – examples from Northern Ireland

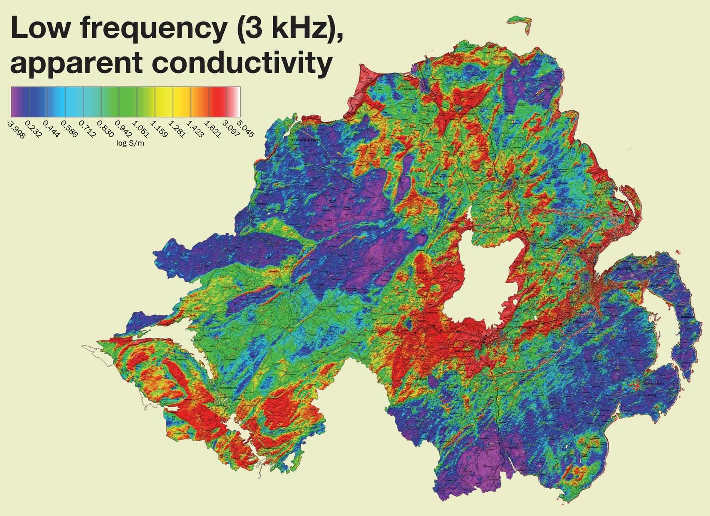
Total magnetic intensity anomaly



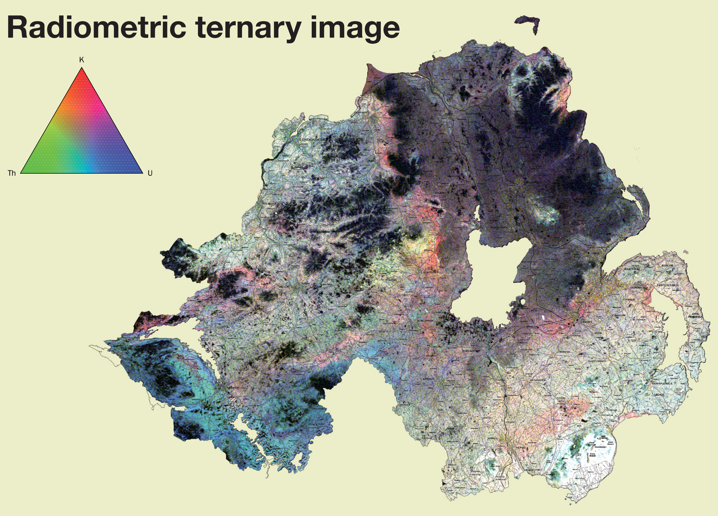
Configuration in 2005

Configuration in 2006

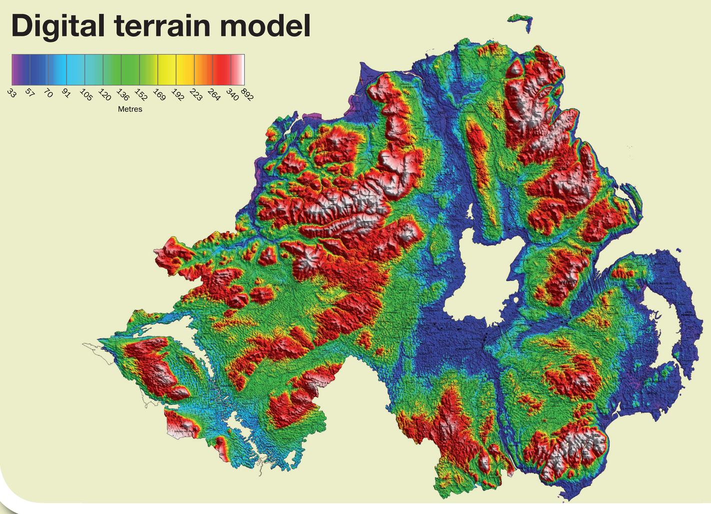
Low frequency (3 kHz), apparent conductivity



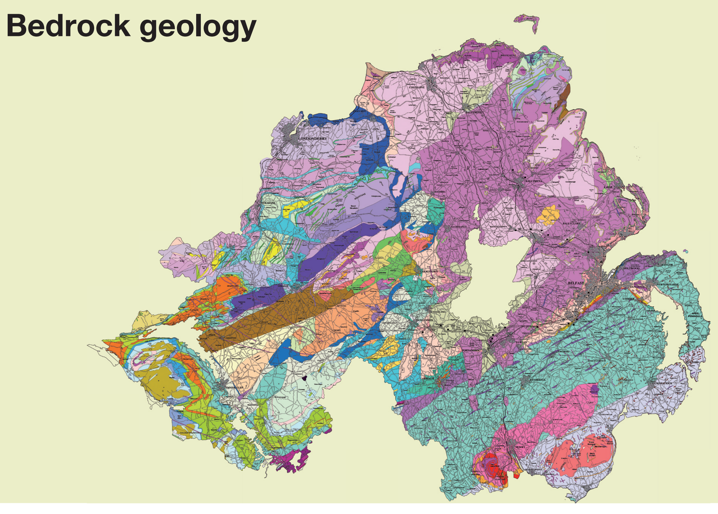
Radiometric ternary image



Digital terrain model



Bedrock geology



The Geological Survey of Northern Ireland (GSNI) has completed the national low-level airborne geophysical survey and geochemical sampling campaigns of the Tellus Project.

The objectives of this project are

- to provide a baseline of information against which to measure future environmental change;
- contribute to sustainable land-use planning decisions by detecting and mapping geological conditions that may be associated with natural hazards and land drainage;
- detect and map certain forms of industrial and agricultural contamination and the conditions under which these might develop;
- help government to comply with the requirements of legislation on the assessment and monitoring of natural resources, soils and waters, including European Framework Directives;
- advance the development of Northern Ireland's natural resource industry and provide the basic geological data and framework for decision-making and development planning.

The geophysical results provide new insights into Northern Ireland's geology, particularly where bedrock is obscured by overburden. Definition of faults, dykes and the major volcanic complexes has been improved. The complementary imagery of magnetics, electrical conductivity and radioactivity facilitate mapping of soils, rock types and certain anthropogenic effects.

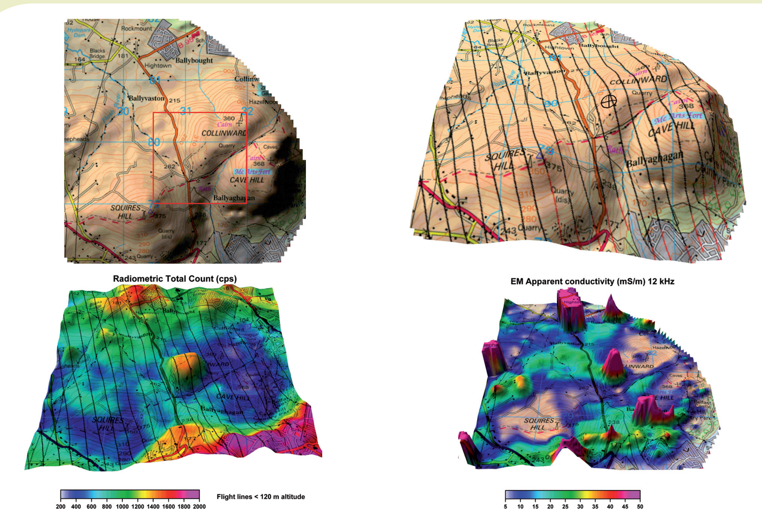
The results have enabled:

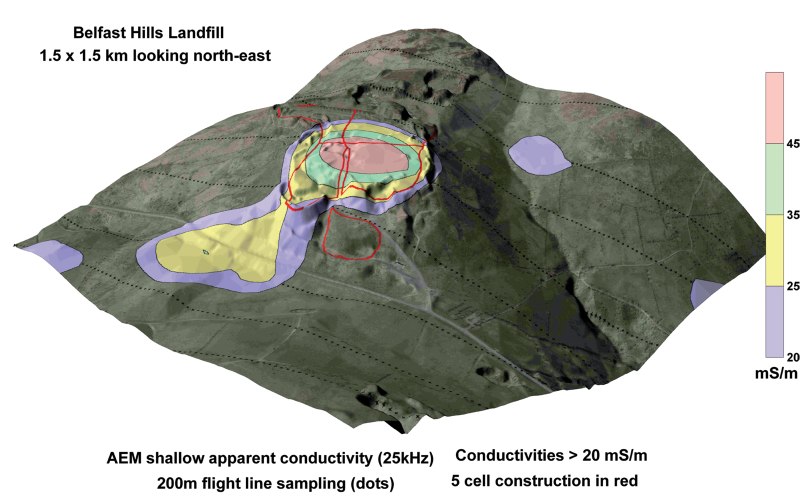
- Identification of new areas of enhanced radon potential by multivariate linear regression analysis of several datasets, including the radiometric channels;
- Mapping of Cs-137 fallout remaining from the 1986 Chernobyl accident and nuclear weapons testing;
- Detection of isolated landfills and mapping of contaminant plumes from landfills and industrial sites, using radiometric and conductivity results;
- Mapping soil organic carbon by statistical analysis of the radiometric potassium channel;
- Estimating the thickness of peat from observed gamma-ray attenuation.

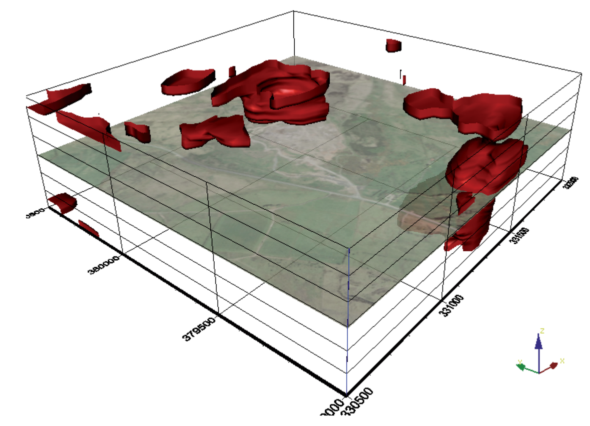
Survey specifications

The survey was flown for GSNI by the Joint Airborne-geoscience Capability, a partnership of the BGS and the Geological Survey of Finland (GTK). The survey was flown with a De Havilland Twin Otter aircraft, used previously for geophysical surveys in Finland and purchased in 2004 by the Natural Environment Research Council. The aircraft is equipped with two magnetometer sensors, 256-channel gamma-ray spectrometer, four-frequency electromagnetic system, laser altimeter and GPS navigation system.

Ground clearance:	56 m (244 m over urban areas)
Line spacing:	200 m
Line direction:	345 degrees
Sampling intervals:	magnetics - 7 m approx
	electro-magnetics - 17 m approx
	gamma-ray - 70 m approx



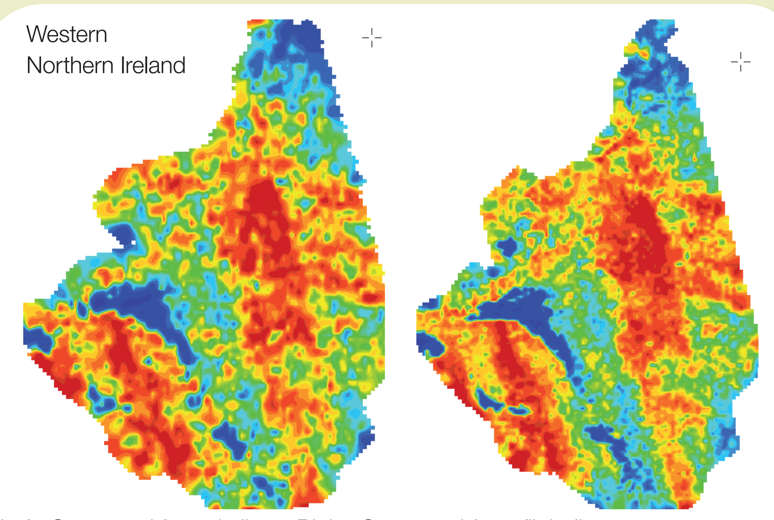




3D model of conductive zones (>55mS/m)

Characterising pollution from landfills

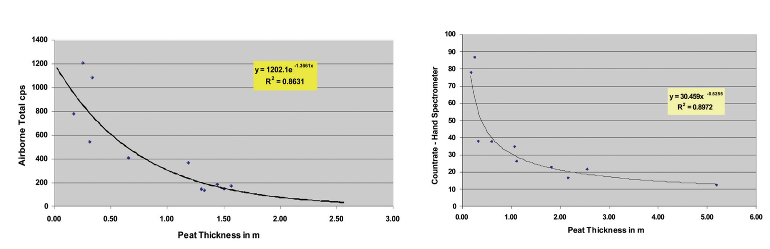
Large landfills, particularly older landfills not underlain by a fluid-retaining membrane, may release contaminating fluids to groundwater. Airborne magnetic, electrical conductivity and radiometric methods may detect pollution downstream of an unprotected site and detect the surface expression of exposed sites. Anomalies were detected by the Tellus survey over certain known dumps. Historically in Northern Ireland, dumps have been established illegally and airborne screening may provide a rapid means of screening remote rural areas for these.



Left: Contoured from tie lines; Right: Contoured from flight lines

Deposition of caesium

Radioactive caesium was deposited over parts of UK after the Chernobyl accident in 1986 and during the period of nuclear weapons testing in 1961–2. The gamma-ray peak of ^{137}Cs at 662 keV was recorded by the survey. The patterns seen in the data are consistent with wet deposition caused by bands of rain intercepting the Chernobyl plume. Comparison of the results with a land-use classification showed that salt marsh areas, forests, natural grassland, pastures and similar classes exhibited higher average ^{137}Cs values, although the range of values seen falls within that expected for the UK. Aspect and relief show correlation with the Northern Ireland ^{137}Cs data at a local scale, but not for the entire ^{137}Cs dataset.

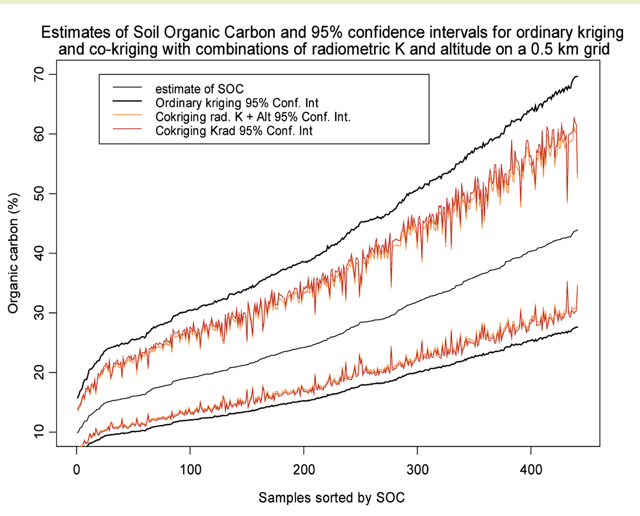


Dalradian section: airborne total count vs peat thickness

Carboniferous section: hand-held spectrometer total count vs peat thickness

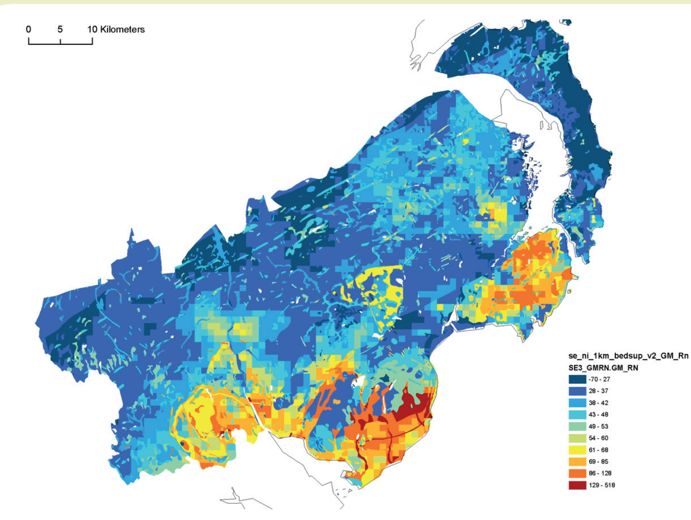
Peat

Peat covers some 11% of the land surface of Northern Ireland. Knowing its extent and depth is important for reforestation, ecological management and carbon storage estimation. The Tellus airborne gamma-ray amplitudes reduce significantly over areas mapped as peat. Measurements of peat thickness have been compared with ground and airborne gamma-ray amplitudes. Early results indicate that the attenuation of gamma radiation may be correlated with peat thickness, at least over homogenous geology, to a depth of 4m. With further calibration over different types of bedrock, it may be feasible to use airborne gamma-ray surveys to estimate average peat thickness over the area of the field of view.



Organic carbon in soil

Regional governments have a statutory requirement to estimate the volume of organic carbon in the soil. A spatial analysis showed a strong negative relationship between the airborne radiometric potassium signal and soil organic carbon sampled on a 2 x 2 km grid across Northern Ireland. As the mineral content of the soil declines the organic carbon content increases. We can use the more intensive airborne survey data to reduce the uncertainty in our estimates of soil organic carbon. In the figure the confidence intervals on the estimates (thin black line) when the radiometric survey data are included (red and orange lines) are much narrower than when these data are not included (the thick black lines).



Radon risk estimation

The probability of houses in Northern Ireland having radon levels above the guideline value of 200 Bq/m^3 is currently estimated only from sparse in-house measurements averaged over 5 x 5 km grid squares. Multivariate linear regression has been tested as a more predictive approach, using Tellus airborne radiometric data, soil geochemistry data and digital geology. There is a generally good agreement between radon maps modelled by this approach and conventional radon mapping. This approach should facilitate improved radon risk estimation.

TELLUS

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Acknowledgements

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EU Programmes

Building Sustainable Prosperity