What is an MRes?

An MRes is a “Masters by Research” degree in which students undertake a one year research project (with a small number of taught courses) supervised by academic members of staff. It is essentially a “mini PhD” in that the projects are all directly related to ongoing departmental research. It is anticipated that the data generated will be published in international peer reviewed journals and the MRes dissertation is expected to be of a commensurately high standard.

An MRes particularly suits students thinking of going on to study for a PhD in the future (a nice one year “taster” experience) or students who would like a MSc degree, but are looking for something that offers more scope to develop in a topic that interests them (more independence, less lectures and exams, but still a range a transferable skills). The standard of work expected is high and ideally we would be looking for students who are on track for a good 2.1 degree or higher.

A sample of the topics available within Physical Geography are outlined below. You are also encouraged to contact staff members to develop your own topic – especially in Human Geography.

Physical Geography Topics

- **Best practices for mapping burned areas** - Dr Kirsten Barrett (kb308@le.ac.uk)
  Satellite-based detections of active fires show us how a fire moves across the landscape. Post-fire, burned area is usually mapped using imagery of the landscape affected by the burn. Some studies have used active fire detections to estimate burned area as a faster, more efficient method than using imagery. The biases involved in using active fire detections will be studied in this analysis to evaluate the two methods of estimating burned area.

- **NDVI and productivity in North American boreal forests** - Dr Kirsten Barrett (kb308@le.ac.uk)
  Remotely sensed vegetation indices are often used to infer various characteristics of forest health and abundance across a broad range of ecosystems. Linking these indices with ground-based observations is an important step in bridging the plot level and the landscape scale. This study will use tree-ring data to generate estimates of tree productivity, which will be compared with vegetation indices from the sites where the trees were harvested.

- **Mapping ecosystem services in Mexico (or another country of choice) from satellite data** - Professor Heiko Balzter (hb91@le.ac.uk)
  This project aims to derive data on the carbon cycle, water cycle and microclimate from digital maps.

- **Geomorphology as a determinant of savannah vegetation communities in Kruger National Park, South Africa** - Professor Heiko Balzter (hb91@le.ac.uk)
  Using high-resolution DEM to understand vegetation types (to be mapped from satellite data).

- **Vegetation phenology analysis with TIMESAT** - Professor Heiko Balzter (hb91@le.ac.uk)
  Looking at greening up and senescence of vegetation as a function of climate data.

- **13C and 18O of terrestrial gastropod shell calcite as a palaeoenvironmental proxy for the Neogene and Late Quaternary of the Western Cape of South Africa** - Dr Andy Carr (asc18@le.ac.uk) and Dr Arnoud Boom (asc18@le.ac.uk)
  The isotopic composition of the carbonate shells of marine and terrestrial organisms have long been used as palaeoenvironmental proxies. The coastal sedimentary sequences of the Western Cape of South Africa preserve the remains of several species of gastropod and offer an opportunity to consider palaeoenvironmental conditions during the Miocene, Pliocene and Late Quaternary. The student will focus on developing an initial data-set for contemporary species, before applying this understanding of modern shell isotope-climate relationships to material sampled from Quaternary-aged sedimentary sequences.
- **Geochemical proxies for palaeo-fires preserved in Rock Hyrax middens** - Dr Andy Carr (asc18@le.ac.uk) and Dr Arnoud Boom (asc18@le.ac.uk)
  This project will seek to develop a proxy record for Quaternary / Holocene fire occurrence/severity as preserved in a unique archive – the fossil latrines of the Rock Hyrax. Assessing the occurrence and severity of vegetation burning within the palaeoenvironmental record is challenging, particularly in the study area (southern Africa) where few suitable sedimentary archives can be found. However, fire is an integral part of ecosystem functioning in these environments and changes in its occurrence are just as significant as past vegetation composition (e.g. fossil pollen) to our understanding of environmental change in this region. The project will involve collaboration with colleagues in Leicester and France and work in the isotope laboratory. It will focus in particular on the use of biomarker and GC/MS analysis.

- **Tropical peatlands** - Professor Sue Page (hodgeog@le.ac.uk) and Dr Arnoud Boom (ab269@le.ac.uk)
  Tropical Peatlands are among the most important terrestrial carbon stores and hence are of major significance in the global carbon cycle. Peat forms under waterlogged conditions but following drainage, it becomes an ideal fuel for fires. Drainage, clearing and agricultural conversion of peat swamp forests (PSF) bring about physical and chemical changes which are largely due to the oxidation and compaction of peat, and alteration of microbial communities. These changes influence the ignition and combustion behaviour of peat. Very little is known of the actual gaseous and particulate emissions produced by burning peat or how emissions vary between pristine, degraded, and converted PSF. The proposed research topic would involve lab analysis of peat samples collected by Dr Thomas Smith (King's College London, KCL) in Brunei on the island of Borneo. At KCL, the peat samples are combusted and the smoke is sampled and measured for concentrations of various greenhouse gases and reactive gases. Subsamples of the peat before and after burning are kept for further analysis. To help explain any variance in these gas emissions between different samples, the MRes student will work in the Department of Geography, University of Leicester to perform chemical composition analysis of the peat and interstitial water in the pre-burn subsamples and the post-burn ash samples.

- **Mapping the quantity and quality of urban green space** - Dr Claire Smith (cls53@le.ac.uk)
  Green infrastructure provides important ecosystem services within the urban environment. It is recognised as an important regulator of climate variables, and can create a more resilient environment in relation to extreme weather events, such as heat waves or pluvial flooding, thereby ensuring optimal functioning of the city population and infrastructure. However, green infrastructure varies both spatially and temporally, and there are limited data related to the role of small (<1 ha) green spaces. This project will use a combination of GIS and remote sensing techniques to determine the quantity and quality of both centralised and decentralised (e.g. private gardens) green space within a UK urban area. The temporal variation of vegetation quality will be assessed according to seasonal and meteorological influences.

- **Mapping the occurrence and impact of past extreme weather events** - Dr Claire Smith (cls53@le.ac.uk)
  This project will use archive evidence (e.g. media reports, interviews with key stakeholders, emergency service data), together with meteorological records to develop a climate impacts profile for the East Midlands region. The qualitative and quantitative data will be used to establish the frequency and impact of extreme weather events. These outputs will subsequently provide the basis for the development of a quantitative extreme event classification scheme which would be applicable beyond the spatial extent of this study. Examining the data spatially, using GIS and spatial analysis techniques, will further assist in the identification of high risk areas and will help to establish priorities for resource allocation.

- **Middle to Late Pleistocene Palaeoclimate Reconstruction, NE Serbia** - Dr Sue McLaren (sjm11@le.ac.uk)
  Near Drmno, NE Serbia there are >25 metre thick sections in interbedded loess (wind-blown sediments) and palaeosols (ancient soils) where mammoth skeletons have been found. These sediments preserve a record of palaeoclimates over more than 150,000 years. This project will use a range of techniques on sediments previously collected from the study area that will contribute in the interpretation of the palaeoenvironments in this highly important Quaternary site. This project will be conducted in conjunction with Prof. Markovic, University of Novi Sad, Serbia; Prof. Smalley & Prof. O’Hara-Dhand, University of Leicester.

- **Background to projects a-c)** - Dr. Jörg Kaduk (jk61@le.ac.uk)
  Peatlands are wetland ecosystems characterised by the progressive accumulation of organic carbon (C). Covering less than 3% of the terrestrial surface, peatlands have accumulated over a third of the global soil organic C pool. The fate of the vast quantities of C stored as peat is therefore critical within the context of contemporary environmental change. The net peatland C balance consists of several flux components: ecosystem-atmosphere fluxes of CO2 and CH4, and losses and gains of dissolved organic C via hydrological pathways. Soil nutrients (N, P) are of large importance for the regulation of these fluxes. Fens are minerotrophic (calcareous) peatlands that have been extensively drained for agricultural landuse. Drainage alters the net fenland C budget and continues to contribute significantly to anthropogenic climate change by transferring large quantities of historically accumulated C directly to the atmosphere as CO2, and via the export of DOC that can be lost to the atmosphere (as CO2 or CH4) via evasion from downstream ecosystems. The ecological restoration (rewetting) of degraded fens is expected to become an increasingly widespread landuse management activity. Although restoration is expected to deliver net C benefits, C
fluxes from restored fens remain poorly quantified and the magnitude of the impacts uncertain.

The Department of Geography and the NERC-funded Centre for Ecology and Hydrology (CEH) have established a long-term programme monitoring C cycle and hydrological processes at the Wicken Fen National Nature Reserve, Cambridgeshire. The projects are offered within this existing framework, the Department of Geography.

Shared travel arrangements for field work can be supported by a PhD student and a technician currently working at the site.

**Project a): The role of soil heat transport in the energy balance of pristine and regenerating temperate fens**
The Department of Geography and the NERC-funded Centre for Ecology and Hydrology (CEH) have established a long-term programme monitoring C cycle and hydrological processes at the Wicken Fen National Nature Reserve, Cambridgeshire. The project is offered within this existing framework, the Department of Geography.

The objective of the project is to develop a spatially explicit numerical dynamical simulation model representing the soil heat uptake, transport and storage in one or two fenland sites (both approx. ¼ km²) in the Wicken Fen Nature Reserve and to explore the use of remote sensing data.

The soil heat dynamics and their spatial heterogeneity represent one source of uncertainty limiting our understanding of ecosystem energy fluxes. Radiation fluxes can be measured quite well and eddy covariance can provide ecosystem scale sensible and latent heat fluxes. There is, however, not much known about the dynamics of soil heat transport and storage and its contribution to the incomplete closure of the energy budget in ecosystem level measurements. An improved understanding of this would help with the interpretation of a large data base of existing ecosystem scale measurements.

The student will have access to a high quality (30 minute) meteorological dataset including radiation, soil heat flux, soil water content and soil temperature in 1-2 locations. During the project on regular site visits (1-2 days per month), measurements should be made of soil water content, soil temperature, radiation exchange, surface temperature which should coincide with satellite measurements of surface temperature. There will be support for setting up the equipment and for the initial field measurements (from the departmental technician). An initial matlab script exists that can be used as a starting point, but it is envisaged that this will be significantly enhanced. Anticipated methods are the adaptation of coefficients on the basis of measurements in partial differential equations that will be numerically solved using existing software packages (e.g. NAG) routines. Software development environment is matlab on alice or spectre.

The student will benefit from joining an established research group within the Department of Geography and a wider project funded by DEFRA on the greenhouse gas exchange of lowland fenlands. The project offers significant potential for the co-authorship of a research publication. Potentially students can exploit the opportunity to build upon existing Departmental links with academics and students working at CEH, the Open University, and the Universities of Leeds and Bangor.

**Project b): The water balance of pristine and regenerating temperate fens (peatlands)**
The objective of the project is to develop a spatially explicit numerical dynamical simulation model representing the development of the water table in one or two fenland sites in the Wicken Fen Nature Reserve.

The student will have access to a high quality (30 minute) meteorological dataset and regular water table observations. There is the opportunity to do some field work in Wicken Fen, but it is not required.

The topography of the Fen should be brought into a GIS system for visualisation. There are LIDOR data and a survey of the Fen, but this could be updated with a more recent survey. The water table could be measured on a regular basis using existing dipwells and coring in addition to the existing data.

A description of an initial water balance model exists, but it is envisaged that this will be updated. Anticipated software development environment is matlab.

The student will benefit from joining an established research group within the Department of Geography and a wider project funded by DEFRA on the greenhouse gas exchange of lowland fenlands. The project offers significant potential for the co-authorship of a research publication. Potentially students can exploit the opportunity to build upon existing Departmental links with academics and students working at CEH, the Open University, and the Universities of Leeds and Bangor.

**Project c): Soil surface CO2 concentrations and fluxes in of pristine and regenerating temperate fens (peatlands)**
The objective of the project is to measure the soil surface CO2 concentration and fluxes spatially explicitly in one or
two fenland sites in the Wicken Fen Nature reserve and relate it to measurements of the ecosystem CO2 exchange. Field work in Wicken Fen is expected.

During fortnightly to monthly field campaigns the student should measure soil temperature and the soil surface CO2 concentration and fluxes spatially explicitly using state of the art equipment from the Department of Geography. In addition the photosynthetic response of the existing plant species should be measured using equipment from the Centre for Interdisciplinary Science.

The student will have access to a high quality (30 minute) meteorological and ecosystem level CO2 flux data set to compare her measurements to.

Using her measurements and the meteorological observations the student should develop a spatio-temporal representation of the CO2 concentrations and fluxes and compare this to the ecosystem level fluxes.

**Project d): Drought leaf-phenology around the world**

Phenology, in particular of plants, has emerged as a hot topic in global change research. This is because it sits right at the interface of the carbon cycle and the physical climate system. Leaf phenology – the appearance and the shedding of the leaves, as well as their amount – determines the growing seasons and hence the ecosystem water and carbon fluxes. This strongly impacts the water and carbon cycle and thus the physical climate. Conversely, the physical climate, temperature, light and soil moisture determine leaf phenology. For predictions of future climate we therefore urgently need a good understanding of the drivers and response of leaf phenology. Our knowledge in this area, is however, very limited, in particular regarding drought phenology. This project will explore the environmental drivers for drought driven leaf phenology.

Remote sensing data will be used to determine large scale leaf appearance and shedding in subtropical (Savannah and grassland) areas around the globe. These times will be related to the environmental conditions in the areas in the first instance and also, based on remote sensing data, allowing us to obtain surface soil moisture. Then model-based data products will be used to explore deeper soil moisture and also root and soil suction for water extraction from the soil. A first product from the project would be an evaluation of the relationship between soil suction and leaf appearance for different ecosystems.

The project is open ended in that such a relationship could be implemented into the land surface model JULES and the consequences of the derived relationship for water and CO2 fluxes can be explored in the context of current or future climate.

This is a very data and computation heavy project. The computational environment is expected to be in the first instance matlab or R on the high performance cluster ALICE of the University of Leicester. This offers the opportunity to work in and gain experience a cutting edge computational environment.