THE UNIVERSITY OF NEWCASTLE AUSTRALIA

DISCIPLINE OF EARTH SCIENCES

HONOURS AND UNDERGRADUATE RESEARCH PROJECTS

2024

Undergraduate Research in the Discipline of Earth Sciences

School of Environmental and Life Sciences

Earth Sciences spans the study of the critical (bio)physical systems that support life on Earth, and control environmental conditions and change on the Earth's surface, and beyond. Research in Earth Sciences has many applications in shaping a sustainable Earth, take a look for yourself here[1].

Earth Sciences staff currently research across the following sub-disciplines:

- Hydrology and hydrogeology (groundwater)
- Climatology and climate change
- Coastal geomorphology and change
- Oceans, waves and coastal hazards
- GIS, spatial science and remote sensing

We encourage undergraduates to get involved in research throughout their degree. By doing so you will learn and develop skills that will provide you with a strong foundation for your future career, whether it be in the industrial, commercial or academic sector. This includes skills in:

- searching for, selecting, and retrieving information from scientific sources
- project management
- experimental research, computer modelling, and field work
- presenting scientific information in a clear and concise manner, both orally and in writing.

There are three main ways to get involved in research:

a) ***Summer Scholarship research project:*** Short paid undergraduate research projects over summer. Scholarships are advertised each year.
b) ***SCIE3500 Research Integrated Learning:*** A 10-unit undergraduate course consisting of a research project supervised by academic staff. Assessment is based on a progress report, a research notebook, a final project report and an oral presentation. The course is open to third year students who have successfully completed at least 140 units and have a cumulative GPA of at least 5.0 and is offered in both semesters. Course outline link here.
c) ***Honours research project:*** A full-year research project after completion of the Bachelor of Science, Bachelor of Environmental Science and Management, Bachelor of Coastal and Marine Science, or Bachelor of Climate Science and Adaptation. A minimum GPA of 5.0 is required for entry into honours. Program handbook link here.

This booklet contains a list of undergraduate research projects currently available in the discipline, arranged by the academic staff member supervising each project. You should discuss potential projects with a prospective supervisor before enrolling or applying for a research opportunity.

1.https://www.geolsoc.org.uk/~/media/shared/documents/education%20and%20careers/Resources/Posters/Geoscience%20for%20the%20Future%20poster.pdf?la=en

A/Prof Hannah Power

Coastal science and hazards on beaches and in estuaries

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A/Prof Hannah Power is a coastal geomorphologist who investigates the beaches, estuaries, rivers, and reefs and examines how processes such as waves, tides, and currents change the shape of our coast over time. Hannah also works on improving predictions of extreme events and hazards such as extreme wave runup, tsunami, and coastal inundation.

Project 1: Extreme water levels in estuaries – driving processes and their timescales

This project will investigate extreme water levels in estuaries and assess the driving processes and their timescales. The project will use existing estuarine and ocean tide gauge data and complement that with additional estuarine hydrodynamic deployments. Data will be analysed to determine how each driving process (e.g., tides, sea level rise, atmospheric pressure, long period coastal trapped waves, and climate drivers) contributes to extreme water levels and their relative frequency, magnitude, and period distributions. These data will be used to assess future risks to estuaries from ongoing sea level rise and thus inform coastal management/planning processes.

Students interested in this project will need to have completed GEOS3220 (Coastal Environments and Processes).

Project 2: Morphological and hydrodynamic influences on extreme wave runup

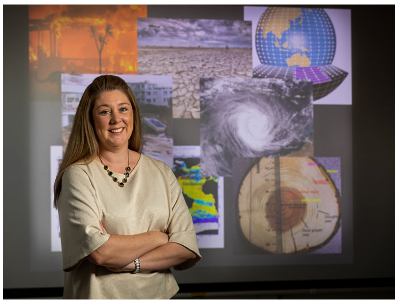
This project will investigate the morphological and hydrodynamic drives of extreme wave runup on sandy beaches. The project will use existing data collected by the Coasts and Estuaries Research Group over the past several years and supplement it with additional, targeted field experiments to further investigate the key drivers of extreme wave runup. Factors such as offshore wave spectra, surf zone hydrodynamics, surf and swash zone morphology, and wave-wave interactions will be assessed as to their relative influence on driving extreme wave runup and on the wave runup distribution. This research will inform coastal management by enhancing predictions of open coast wave runup, hence improving predictions of open coast inundation and dune erosion.

Students interested in this project will need to have completed GEOS3220 (Coastal Environments and Processes).

Project 3: Wave overwash hazards and risk management on coastal rock platforms

This project will investigate the conditions that drive ocean wave overwash on coastal rock platforms. The project will use an extensive remote sensing and hydrodynamics observation dataset collected at the famous Figure Eight Pools site in the Royal National Park south of Sydney to assess how water level, wave height, wave period, and offshore directional wave spectra influence the frequency and magnitude of wave overtopping that poses a hazard to visitors on the rock platform. Hydrodynamic data and remotely sensed data will be analysed to investigate the roles of offshore hydrodynamic conditions and platform morphology on wave overtopping. A predictive hazard warning system will be evaluated and further developed to apply to other coastal rock platforms in NSW. New field data will be collected at dangerous rock platforms in the Newcastle region to inform the modelling. This research will inform rocky shore coastal management and safety advisories for recreational visitors to rock platforms for activities such as tourism and rock fishing.

Students interested in this project will need to have completed GEOS3220 (Coastal Environments and Processes). This project is a joint project with Dr Mike Kinsela.



A/Prof Danielle Verdon-Kidd

Climate science, hydrology and palaeoclimatology

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A/Prof Danielle Verdon-Kidd is researching the nature and triggers of extreme weather events, such as droughts, bushfires and storms to help our nation better prepare for what lies ahead. Lying at the nexus of climate science, hydrology and palaeoclimatology, Danielle's research seeks to understand what causes climate-related disasters, and what can be done about them.

Project 1: Unveiling the Ancient Wisdom of Murray-Darling's Timeless Trees through Radiocarbon Dating and Viability Analysis

In the vast expanse of the Murray-Darling Basin, ancient sentinels stand testament to the region's enduring ecological history. Old trees, some dating back centuries, play a crucial role in preserving the basin's unique biodiversity and maintaining ecosystem balance. This project will employ advanced techniques, such as radiocarbon dating, to unravel the age of these trees, peeling back layers of time to reveal the stories embedded in their rings.

This research will allow us to appreciate and protect these venerable trees, ensuring they continue to thrive and contribute to the ecological harmony of the Murray-Darling Basin. Students interested in this project will need to have completed GEOS2161 (Spatial Science).

Project 2: Trends in tropical cyclone behaviour and their changing impacts on coastal cities of African nations

Tropical cyclones (TCs) represent one of the most significant climate hazards effecting a broad region of the global population located in the tropics. As a developing region with relatively poor disaster warning, preparedness and coping strategies, African nations are in some respects more vulnerable to TC disasters than regions with robust disaster risk reduction and coping strategy initiatives. For example, in March 2019, TC Idai made headlines as one of the most severe storms to have made landfall in Mozambique (with ~1,000 deaths). This makes it the most deadly cyclone ever to have made landfall on the southern African subcontinent.

This project will assess recent trends in TCs impacting the African continent and determine which large-scale conditions that are responsible for seasonal variability in TC formation and track characteristics. Students interested in this project will need to have completed GEOS2161 (Spatial Science) and ideally SCIE2223 (weather and waves).

Project 3: Compound climate extremes effecting global food bowls

The Murray Darling Basin (MDB) is well known at the nation's food bowl, supporting ~40% of Australia's agriculture. Similarly, across the globe there are other equally significant agricultural regions supporting large populations. These 'food bowls' are sensitive to climate driven extremes, such as droughts, insect attack, flood and fire. In some cases more than one climate extreme may impact individual regions (known as compound events). Multiple failures across global food bowls could therefore be catastrophic in terms of world food supply.

This project will investigate the risk of compound events to global food bowls by studying a range of global climate datasets. Students interested in this project will need to have completed GEOS2161 (Spatial Science).

Project 4: What causes droughts to break in Australia?

Drought in Australia places a major strain on the agricultural and water resource sectors, causes major economic and social losses. A prime example of this was the 2016-2019 drought that crippled much of NSW agriculture. This drought was also a precursor to the summer 2020 bushfires, which was eventually broken by wet conditions in early 2020. Improved knowledge of the climate mechanisms controlling drought periods will aid in developing robust management practices designed specifically to deal with such events. While much is known about what causes drought onset, less is known about the weather patterns responsible for ending prolonged drought periods.

This project will use synoptic backtracking methodologies to investigate the sources of drought breaking rains for eastern Australia. Students interested in this project will need to have completed GEOS2161 (Spatial Science).

Dr Mike Kinsela

Coastal geomorphology, coastline evolution, marine geology

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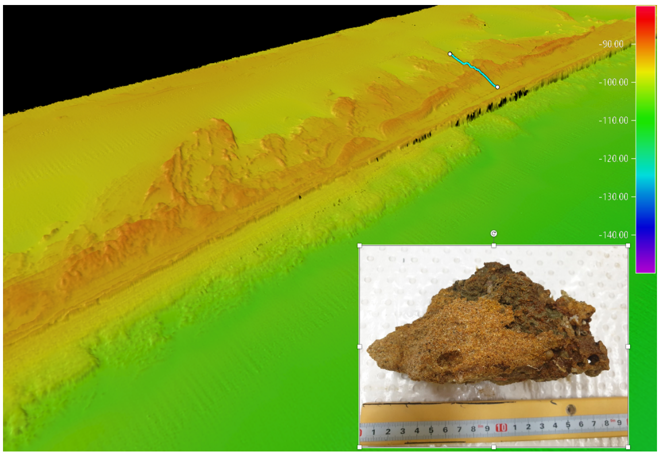
Dr Mike Kinsela is Lecturer in Coastal & Ocean Geoscience with a focus on coastal geomorphology and change. He researches the formation and evolution of coastal barrier-estuary systems, which include, beaches, dunes, inlets, deltas and the coastal seabed. Mike maps, samples and simulates these systems using remote sensing (e.g., laser scanners, UAVs, echosounder seabed mapping), sediment sampling and spatial analysis & modelling. Previously working as a coastal research scientist in government, he is motivated to develop a better understanding of and ability to predict coastal change and hazards, to shape better coastal futures in a changing climate.

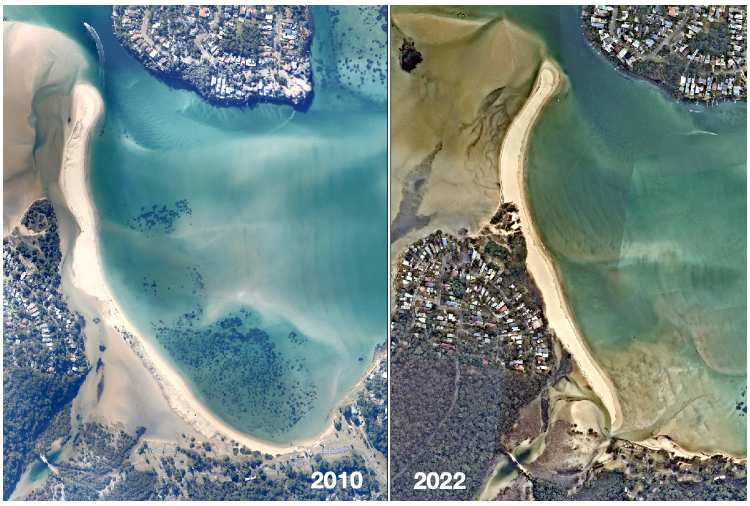
Project 1: Coastal sand connectivity and future shoreline change in southeastern Australia
The resilience and response of sandy coasts to rising sea levels will vary between locations and depends on the types and availability of sediment in the beach system. This project will investigate the sources, sinks and pathways for sediment transport and connectivity between the coast and shelf, and alongshore between adjacent compartments, along the NSW mid-north coast. High-resolution seabed mapping (Lidar, multibeam echosounder) and ground-truthing (sediment grabs, underwater video) data will be used to study the secrets of the seafloor. Seabed geomorphology, sediment bedforms, sedimentology, and stratigraphy will be investigated to identify sand pathways and the dynamics of modern coastal sedimentary systems. There is also potential to study sand bypassing processes around headlands using hydrodynamic observations and wave modelling. The research will inform the development of quantitative sediment budgets that are needed to model future shoreline change and coastal erosion under a changing climate.

Project 2: Drowned coasts from lower sea levels – climate influences on coastal change



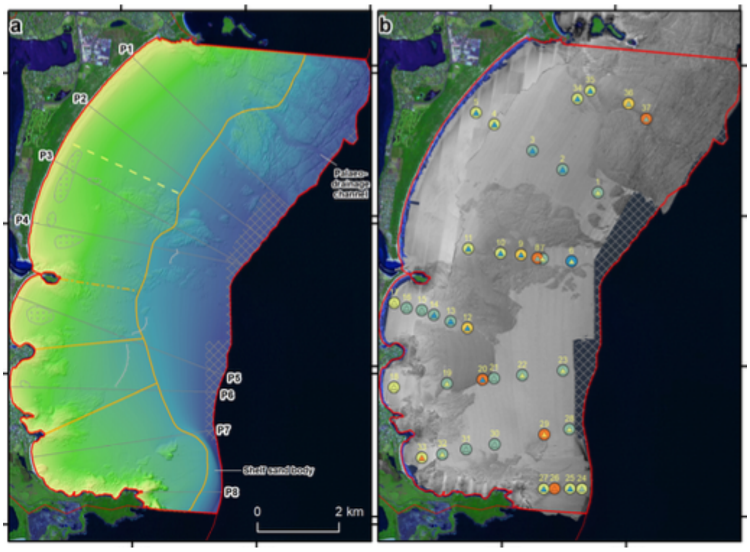
Only 20,000 years ago, sea levels were 120 m lower than today and the Australian coastline was located many kilometres seaward of its present position. Indigenous Australians were living on today's drowned continental shelf and would have migrated inland over generations as sea levels rose over 100 m rapidly due to the melting of Earth's ice caps after the last glacial maximum. Sea levels have fluctuated between those positions over hundreds of thousands of years, leaving behind drowned coasts on the continental shelf. This project will investigate the origins and evolution of drowned coastal landforms (e.g., beaches, dunes) and sediment deposits forming Barwon Bank, on the continental shelf of southeast Queensland. Marine geology and geophysical data collected during the 2022 *RV Investigator* research voyage, and earlier voyages, will be analysed to study the geomorphology, sedimentology and stratigraphy. A focus will be on reconstructing old coastlines from different sea levels to investigate if this region was the terminus of the great east coast northward sand transport system (and the interface to the Great Barrier Reef carbonate province) at lower sea levels, as K'gari (Fraser Island) is during the present highstand sea levels.

Project 3: Resilience of coastal dunes to storms and sea level rise – threshold responses



Coastal dunes provide critical buffers for moderating shoreline change caused by storms and sea level rise. While sea level has been essentially stable for the past several thousand years, it is now rising at the fastest rate since the end of the last glacial maximum. This can allow increased wave attack of previously stable dunes, leading to threshold (or tipping-point) responses. For example, this estuarine barrier-spit ‘rolled over’ and became attached to the mainland in recent years, opening a new inlet to the backbarrier lagoon. This project will investigate the conditions for wave overtopping, washover, rollover and break-through of estuarine and open-coast sand barriers, and their sensitivity to storms and sea levels for current and future scenarios. Historical coastal change data (aerial and satellite imagery) and recent morphological survey data will be analysed along with coastal hydrodynamic (waves and tides) to investigate past and potential future tipping-point changes in different settings. The research will inform coastal planning and management by helping to identify and predict future threshold changes.

Project 4: Mapping coastal seabed geomorphology and geo-historical coastal change



Until recently the coastal seabed off the NSW coast was largely unknown apart from general bathymetry collected for navigation purposes. During the past 6 years NSW Government has mapped much of this area in high-resolution to inform coastal planning & management practices. This project will investigate and analyse detailed seabed mapping and sampling data to characterise the geomorphology of the shoreface and inner-continental shelf. The geometry of the coastal profile and the distribution of different sediment types are suspected to influence coastal change in the past, present, and future. Geo-historical evidence and records of coastal change will be compared with the adjacent seabed geomorphology in different settings to identify any relationships and trends that could help inform predictions of future coastal change. The balance of onshore-offshore sediment transport, crucial for predicting future coastline change, will be a focus of the analyses. The research will be carried with the Department of Climate Change, Energy, the Environment & Water (NSW).

Students interested in any of these projects will benefit from completing the following courses:
- GEOS2161 (Spatial Science)
- GEOS2080 (Earth Sciences Fieldwork)
- GEOS3220 (Coastal Environments and Processes)
- GEOS3250 (Advanced Spatial Science)

Dr Chris Owers

Remote sensing, landscape change, biogeography

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Chris is a Spatial Scientist, and a specialist in using remote sensing to generate critical information about environmental change. Dr Owers has broad interests using remote sensing in environmental applications including coastal science, biogeography, geomorphology, carbon storage, biodiversity, and ecosystem services. He has expertise in using a variety of remote sensing technologies including Earth Observation, airborne imagery, Lidar (Light Detection and Ranging), TLS (Terrestrial Laser Scanning), as well as state-of-the-art analytics such as machine learning, deep learning, time-series analysis, and 3D modelling. Chris is keen on understanding spatio-temporal dynamics of the natural world captured through remote sensing technologies.

Project 1: Towards supratidal extent mapping of Australia
The lack of continental-wide information on supratidal forests is a significant missing link in knowledge of the distribution of coastal blue carbon ecosystems in Australia. Without the ability to classify supratidal forests using remotely sensed imagery, it is currently not possible to identify where this ecosystem exists across Australia or to track changes over time, including increases in extent from restoration projects. This project will help develop a national supratidal forest mapping workflow and associated spatial datasets for Australia. The outputs from this project will look to integrate into Australia's Ocean Accounts, providing a missing piece in national mapping and reporting on Australia's ocean-based natural assets.

This project will be co-supervised by Dr Rafael Carvalho. Students interested in this project will need to have completed GEOS2161 (Spatial Science).

Project 2: Mapping the 'woodiness' of our world
Vegetation plays and important role in the global carbon cycle. Identifying and understanding vegetation dynamics, principally carbon stored as biomass in vegetation wood and leaves, is critical for global climate modelling. We can measure this from space using NASA's Global Ecosystem Dynamics Investigation (GEDI) or ESAs Sentinel-1 Synthetic Aperture Radar (SAR) These platforms offer untapped potential due to their unique measurements and high spatio-temporal collection. In this project, you will explore the use of SAR/GEDI to measure vegetation structural attributes, an important variable in biomass density, and calibrate this to on ground measurements of 'woodiness'.

This project will work closely with CSIRO as well as international partners in the UK. Students interested in this project will need to have completed GEOS2161 (Spatial Science).

Project 3: Towards an Australia-wide remote sensing approach to understanding coastal dune activity

Several studies have established patterns and phases of dune activity around Australia's coastline, relating these patterns to a range of environmental and anthropogenic forcings. However, many of these have been on a local scale and often relied on manual processes. In this project, you will develop a machine learning approach that will enable an Australia-wide mapping framework to understanding dune activity from the Landsat archive. The project will develop methods to distinguish bare sand (i.e. active dunes) from vegetated dunes and map changes in the extent of bare sand over time (1987-present). The outcome will be an improved understanding of coastal dune activity over three decades and development of a methodology that can be applied on a continental scale.

This project will be co-supervised by Dr Tom Oliver (UNSW ADFA). Students interested in this project will need to have completed GEOS2161 (Spatial Science).

Project 4: Better *blue carbon* assessments

Coastal ecosystems such as mangroves and saltmarsh (termed 'blue carbon' ecosystems) are recognised as highly valued natural systems that can help mitigate the impacts of global climate change. This is due to their high carbon sequestration rates, exceptionally long-term burial, and valuable biodiversity co-benefits. These important ecosystem services provide strong incentive for conservation and restoration, particularly as part of national approaches to carbon offsetting and voluntary carbon markets. Critically, we need to know how much carbon is in an area, both in biomass and in the sediment, to facilitate emission offsetting markets. Several approaches have been developed over the last 5-10 years, however many do not account for inherent coastal wetland dynamics. In this project you will develop an approach to upscaling biomass and carbon stocks based on coastal wetland dynamics. This will then be compared to previous methods with a view to demonstrate the approaches at large scale using Australia's mangrove and saltmarsh timeseries maps.

Students interested in this project will need to have completed GEOS2161 (Spatial Science).

Dr Gabriel Rau

Hydrogeology, hydrogeophysics, groundwater resources

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Dr Gabriel Rau has a passion for designing specialist field and laboratory experiments, acquiring, compiling and interpreting geoscience information using advanced data science tools provided through the Python programming language. His work aims to develop and apply methods for the quantification of subsurface processes and properties, leading to improved fundamental process understanding. This includes water flows across the surface/subsoil boundary and the impact of underground resource extraction.

What is your interest related to groundwater systems?
Bring your skills and ideas and we will find a suitable project that can enhance your skills.

Other topic ideas:

- **The role of groundwater in supporting coastal wetlands**
  Groundwater is a vital force in coastal wetlands, playing a crucial role in maintaining their hydrological balance, buffering against extreme conditions, and influencing nutrient cycling. It acts as a stable water source, impacting surface water levels, salinity gradients, and vegetation dynamics. Groundwater's contribution is essential for sustaining biodiversity and ecological resilience in coastal wetland ecosystems, emphasising the need for thoughtful conservation and management strategies especially because sea levels are projected to rise due to climate change.
- **Quantifying hydraulic and geomechanical properties using the groundwater response to Earth tides and atmospheric pressure**
  Sustainable subsurface resource management demands a deep understanding of processes and properties. Predicting the impact of long-term climate-related changes on the global subsurface water balance is challenging due to limited knowledge of hydro-geomechanical properties' spatial distribution. I'm advancing Passive Subsurface Characterisation (PSC), using Earth tides and atmospheric forcing signatures in pressure measurements to quantify hydro-geomechanical processes. Objectives include validating PSC, automating its application to existing datasets, and establishing a global database of hydro-geomechanical properties. The aim is to integrate large-scale surface models with the subsurface, enhancing predictions of groundwater balance changes in climate change scenarios.
- **The spatiotemporal dynamics of water movement through the critical zone of drylands**
  In drylands (semi- to hyper-areas) water resources are scarce, and groundwater sustains human activities and the environment. The Earth's critical zone is located between the atmosphere and groundwater as one of the largest water stores. Interactions through this zone constantly change in space and time and are difficult to investigate. Quantifying hydro-geophysical processes such as water fluxes across this interface is a prerequisite for sustainably managing Earth's resources under a changing climate. My research objective is to better understand and quantify the spatiotemporal dynamics of water movement through the critical zone.