Student proposed?	N	Not applicable
ID	**RAV-05**	
SUPERVISOR	**VERRINDER**	
TITLE	**SHARC project: Photo-synthetically available radiance (PAR) measurement**	

DESCRIPTION

Background to the project

The distribution of sea ice in the Marginal Ice Zone (MIZ) in the Southern Ocean (SO) has a significant effect on global climate patterns, but our understanding of this unique region suffers from a lack of Antarctic seasonal in situ measurement data, especially over the winter season (Kennicutt II et al., 2019; Parkinson, 2004). Sea ice acts as a physical and reflective boundary between the atmosphere and ocean, which has an effect on heat transfer to the ocean and energy budget available to phyto-plankton below the ice. There has been limited measurement of solar radiative transfer through sea ice in different seasons in the polar regions (Katlein et al., 2020), with virtually no in situ measurements in the Antarctic. Recent studies by Hague and Vichi (2020) show phyto-plankton growth under sea ice during late winter which indicates that there is radiative transfer through the sea ice even in seasons of highest ice cover. Photo-synthetically Active Radiation (PAR) sensors are traditionally very expensive, making these measurements difficult. Robust and affordable radiative sensors would improve our ability to quantify radiative transfer through sea ice. Katlein et al. (2020) developed a radiative sensor chain based on off-the-shelf photo diode sensors for the Arctic region and the goal of this project is to extend this work for an Antarctic implementation.

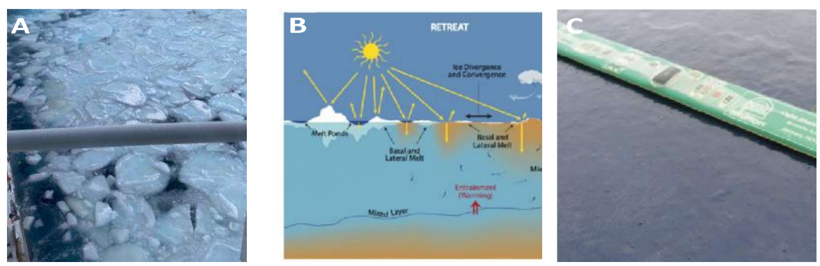

Figure 1: (**A**) Sea ice in the Marginal Ice Zone in the Southern Ocean; (**B**) A schematic illustrating solar radiative transfer in the Arctic sea ice region. Taken from (Lee et al., 2017).; (**C**) An example of an optical PAR sensor chain. Taken from (Katlein et al., 2020).

Subject of investigation

This project focuses on the design of a optical sensor chain based on off-the-self photo diodes which can be used to measure radiative transfer through Antarctic sea ice and can be fitted to the UCT ice-tethered buoy. The system must provide a reliable and efficient measurement throughout a mission in the remote Southern Ocean (up to 6 months) in harsh operating conditions. As part of the design process, a comprehensive evaluation of how this measurement variable is expected to behaviour in this region is needed and should be investigated. The system must be robust to changing environmental conditions (temperature, moisture, ice), fit in the physical space available, with a focus on power efficiency. It is expected at the end of this project that the student will have designed, prototyped, calibrated and tested the system under a variety of laboratory conditions.

DELIVERABLES	**Objectives** The main objectives of this project are: (a) Understand the requirements of the project (b) Conduct a literature review of previous work in this field and critically evaluate current technology/research (c) Review and gain an understanding of how this variable is expected to change over varying time periods (1 sampling period, hourly, daily, seasonally etc.) (d) Produce a detailed set of specifications for the platform based on data sheets, project requirements and previous prototypes. These specifications must accommodate multiple operating modes, variation in behaviour based on temperature variation. (e) Design a prototype photo-synthetically active radiation sensor chain (f) Simulate the system under a variety of operating conditions and through a series of experiments designed for this purpose by the student (g) Test and evaluate the system performance based on a performance metric (h) Discuss the performance of the system, draw conclusions and make recommendations for future improvements **Deliverables** (a) A literature review report and detailed project statement and plan (Hand-in 2 weeks from the initiation of the project) (b) Weekly reporting of project progress and plans to the supervisor through an agreed upon communication platform, which could include online meetings (c) A prototype PAR sensor chain that can be critically tested and evaluated (d) A research project report, following the Department of Electrical Engineering Final Year Project report guidelines (e) Satisfactory completion of all Engineering Council of South Africa's Graduate Attributes (ECSA GAs) (f) Poster summarising the research project report
SKILLS/	Strong mathematical and programming skills for the algorithm development. MATLAB
REQUIREMENTS	
GA 1: Problem solving *Identify, formulate, analyse and solve complex* engineering problems creatively and innovatively*	*The design, integration, and control of the PAR sensor for a platform working in this environment is nontrivial. The student will need to solve this problem given cost, size, power, and environmental constraints.*
GA 4 Investigations, experiments and analysis** *Demonstrate competence to design and conduct investigations and experiments.*	*The student will need to evaluate and test each part of the parameter extraction pipeline. These experiments must be rigorously designed and carefully conducted. Experimental protocols must be noted. These experiments must be reproducible. Experimental data must be recorded alongside metadata in a retrievable format and must be linked to the report. These data must be analysed and summarised and suitable conclusions drawn.*
EXTRA INFORMATION	SCALE Experiment PlanktoScope M. Hague and M. Vichi. Southern Ocean biogeochemical Argo detect under-ice phytoplankton growth before sea ice retreat. Biogeosciences, 18(1):25–38, 2021 C. Katlein, L. Valcic, S. Lambert-Girard, and M. Hoppmann. New insights into radiative transfer within sea ice derived from autonomous optical propagation measurements. The Cryosphere, 15(1):183–198, 2021 C. L. Parkinson. Southern Ocean sea ice and its wider linkages: insights revealed from models and observations. Antarctic Science, 16(4):387–400, 2004 M. C. Kennicutt II, et al. Sustained Antarctic research: A 21st century imperative. One Earth, 1(1):95–113, 2019
BROAD Research Area	Instrumentation, electronic design, embedded system, optical sensing.
Project suitable for ME/ ECE/EE/ALL?	ALL

Ethics clearance questionnaire

		Yes	No
Q1	Does this project involve data collection		X
Q2	Does this project involve utilizing a third-party data set		X
Q3	Does this project utilize machine learning (ML) or artificial intelligence (AI)?		X
Q4	Does it exceed the minimum risk defined here: Link [Answer is No here if your project does not utilize ML and AI]		X
Q5	Does this project involve external parties, funders, etc		X

Answer the following questions if you answer "**Yes**" to any of the above questions. If the answer is "**Yes**" to **Q1**, please answer the following questions:

		Yes	No
Q6	Are there humans or animals directly involved in the data collection process or contains any identification information		X

If the answer is "**Yes**" to **Q2**, please answer the following questions:

		Yes	No
Q7	Are the third-party data used anonymous (data does not contain human or animal-related information?)		X
Q8	Are the third-party data used from an open source?		X
Q9	Are the third-party data used from a different research group?		X
Q10	If the answer to **Q9** is "**Yes**", do you have the approval to use third-party data sets? Attach the proof to PSQ application.		X

If the answer is "**Yes**" to Q5, please answer the following questions:

		Yes	No
Q11	Have you signed an MOU between the parties [If Yes, attach the proof to PSQ application.]		X
Q12	Will there be a chance for any conflict of interest between the parties? [If Yes, provide details of the issue and your plan to solve it]		X

***NOTE: Complex engineering problems** require in-depth fundamental and specialized engineering knowledge and have one or more of the characteristics:

- are ill-posed, under- or over specified, or require identification and refinement;
- are high-level problems including component parts or sub-problems.
- are unfamiliar or involve infrequently encountered issues.

and their solutions have one or more of the characteristics:

- are not obvious, require originality or analysis based on fundamentals.
- are outside the scope of standards and codes.
- require information from variety of sources that is complex, abstract or incomplete.
- involve wide-ranging or conflicting issues: technical, engineering and interested or affected parties.

****NOTE: GA 4:** The balance of **investigation and experiment** should be appropriate to the discipline. Research methodology to be applied in research or investigation where the student engages with selected knowledge in the research literature of the discipline. An **investigation differs from a design** in that the objective is to produce knowledge and understanding of a phenomenon and a recommended course of action rather than specifying how an artifact could be produced.