Analyse tropical cyclone properties from satellite imagery ENG/FIT4701 Project Proposal

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Project type: Consulting Project

1 Introduction:

Tropical cyclones are one of the most destructive weather phenomena on Earth, capable of causing widespread devastation and loss of life. These storms are complex systems that require specific environmental conditions to form and intensify, such as warm sea surface temperatures, low vertical wind shear, and high atmospheric moisture content (Kossin et al., 2017). In recent years, the frequency and intensity of tropical cyclones have increased globally, with notable events such as Hurricane Katrina, and Cyclone Idai causing significant damage to infrastructure and the economy (Emanuel, 2017).

To better understand and mitigate the impacts of tropical cyclones, there is a critical need to accurately measure and predict their structure, intensity, and size parameters. Traditionally, these measurements have been made using subjective methods based on visual interpretation of satellite imagery (Piñeros et al., 2008), which can be prone to errors and biases. However, recent advances in remote sensing technology and data processing techniques have opened new opportunities for objective and automated analysis of tropical cyclones using satellite imagery.

1.1 Background:

Several limitations exist in the current techniques for tropical cyclone analysis and forecasting. One major challenge is the lack of accurate and consistent data, which can be affected by various factors such as satellite observation angle, cloud cover, and instrument noise. Another limitation is the complexity of the tropical cyclone system itself, which involves multiple interacting processes (Piñeros et al. 2008) that are difficult to model and predict accurately. For example, the traditional Dvorak technique (Piñeros et al., 2008) used for estimating tropical cyclone intensity is based on visual inspection of satellite images and requires significant expertise and training. To overcome these limitations, there is a need for advanced techniques that can process large volumes of data and extract relevant information automatically and objectively, while also accounting for the complex dynamics of the tropical cyclone system.

1.2 Previous Studies:

The collection of papers given to us all focuses on the use of satellite imagery and image processing algorithms to detect, track, and predict the formation, structure, and intensity of tropical cyclones.

Several studies, such as those by (Hu et al., 2020) and (Ritchie et al., 2012), have explored the use of the Deviation Angle Variance (DAV) technique for estimating various parameters of tropical cyclones from infrared image data, including their size and intensity. Additionally, (Hu et al., 2020) has investigated the application of the DAV technique for short-term intensity forecasting, while (Wood et al., 2015) and (Rodríguez-Herrera et al., 2015) have examined the use of the technique for detecting tropical cyclogenesis. These studies could have important implications for disaster response and preparedness, as accurate and timely predictions of tropical cyclone behaviour can help to mitigate the impacts of these potentially devastating events.

1.3 Problem Statement:

Despite the significant progress made in analysing tropical cyclones using satellite imagery, there is still a need to improve our understanding of these storms' behaviour. This project aims to use objective measures derived from satellite imagery to estimate tropical cyclone structure, intensity, and size parameters. By studying these parameters, we can better understand the physical processes that occur within the cyclone, which could improve our ability to predict their path and intensity accurately. The tools developed in this project aim to address these challenges and contribute to our understanding of tropical cyclones, ultimately improving disaster preparedness and response efforts.

2 Aims and Objectives

2.1 Aims:

The aim of the project is to develop a semi-real-time remote-sensing-based visualization tool for tropical cyclone tracking, intensity estimation, and wind field estimation.

2.2 Objectives:

1. Identify the specific data parameters required for calculating the Deviation Angle Variance (DAV) for satellite-based infrared imagery.
2. To design and implement advanced data visualization techniques that can accurately represent the patterns of tropical cyclones, including time series plots, and interactive maps, using Python tools such as NumPy, Pandas, and Matplotlib.
3. To develop a tracking algorithm that can automatically detect and track tropical cyclone features in the North Atlantic region, using machine learning techniques such as object detection and tracking, and evaluate its accuracy and robustness using statistical metrics.
4. To create an intensity algorithm that can reliably estimate the strength and intensity of tropical cyclones in the North Atlantic region, using a combination of physical models, statistical methods, and machine learning algorithms, and validate its performance using independent datasets and benchmark tests.
5. To develop the wind field algorithm for estimating the wind field of storms based on satellite IR image data and storm parameters.
6. To create a python package that is well-documented, modular, and easily customizable, to allow researchers to adapt and extend the algorithms to suit their specific research needs.

3 State of Field

Tropical cyclones are intense low-pressure weather systems that are formed over warm ocean waters (Piñeros et al., 2011) and are characterized by strong winds, heavy rainfall, and storm surges. The impacts of tropical cyclones can range from flooding, wind damage and infrastructure destruction, making it crucial to have a deep understanding of their behaviour and intensity to prepare and respond effectively to these storms.

The measurement of tropical cyclone structure and intensity is a fundamental aspect of tropical cyclone research. Measuring the structure and intensity of tropical cyclones enables experts to track their paths and intensities. A traditional method for measuring tropical cyclone intensity is the Dvorak technique. The Dvorak technique, developed in the 1970s is widely used as it does not require direct measurements of the tropical cyclone (Piñeros et al., 2008). Rather, the satellite-based measurement is used, which is especially helpful in ocean basins where direct measurements are not feasible. The Dvorak technique "uses infrared (IR) and visible imagery" to estimate the intensity of a tropical cyclone (Piñeros et al. 2010). The Dvorak technique was successful in estimating tropical cyclone intensities as it can observe and describe the dynamics and structure of the tropical cyclone. This paved the way to develop more satellite-based remote-sensed observations.

The deviation angle variance technique (DAV) is a widely used method for estimating the intensity of tropical cyclones based on satellite-based data. It uses geostationary infrared brightness temperature data (Rodríguez-Herrera et al, 2015). The concept behind DAV is that as a tropical cyclone intensifies, the variance around the eye of the storm becomes more uniform. On the other hand, there is more variance in weaker tropical cyclones. This occurs as the stronger the storm, the more organised the structure will be.

To compute the DAV a few steps are required. Firstly, the gradient of each infrared image is computed over the entire scene. Then the angular deviation between the gradient and a radial from the reference point is calculated. This is done for every pixel/data point that is provided. The DAV is obtained as a single quantity that characterises the symmetry of the infrared cloud scene for the reference point. The DAV values located at the centre of a tropical cyclone are negatively correlated with tropical cyclone intensity. (Ritchie et al. 2014)

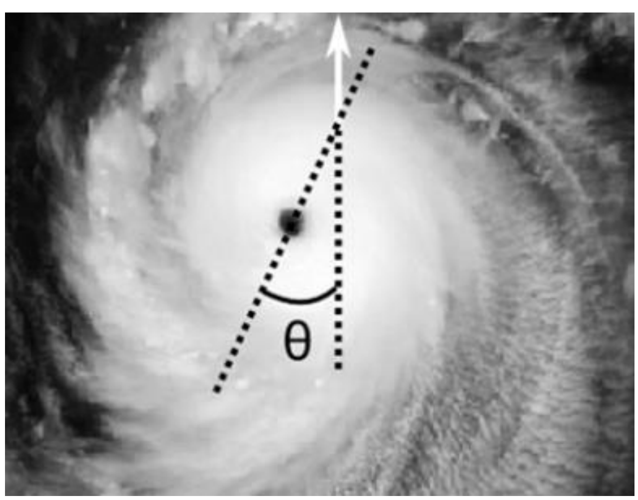

Figure 1: Deviation-angle calculation for a gradient vector

The reason why DAV is useful is because it produces an objective estimate of the intensity of a tropical cyclone without the need for direct measurements of parameters that require manual handling. Being a remote-sensing based technique allows it to be used for real-time weather situations, regardless of their size or location. However, as DAV is computed from satellite imagery, it is highly dependent on the quality of the image. Aspects such as image noise, resolution, and satellite viewing angle relative to the system of interest need to be taken into consideration when taking inputs (Hu et al. 2020a, 2020b). Moreover, DAV can provide an estimate of the intensity of a cyclone at a given point in time. It may be used by forecasters to estimate the nature and extent of the cyclone as well as short term predictions of future intensity (Hu et al. 2020a, 2020b), but it cannot be used to predict future track.

Software will be created to download infrared images, calculate the DAV map from those images over the North Atlantic Ocean basin. Separate software packages will then be developed to use the DAV map to track cloud clusters that have potential to develop into tropical cyclones, estimate intensity of existing tropical cyclones, and estimate the two-dimensional surface wind field. A GUI interface will be developed to visualize all components of the software. As the DAV is the key to all aspects of the system, an algorithm will first be developed that efficiently accesses the data and computes the DAV map. The following is a high-level overview of the basic steps to compute DAV and then produce the other components of the system:

1. Image processing: Require reducing image noise and downscaling the raw satellite image data.
2. DAV calculation: calculate the DAV for each pixel and map back to the reference pixel to produce a “map of variances” that corresponds to the original Infrared image.
3. Visualization package: Develop a software package with GUI interface to visualize the infrared image and DAV map. As other software packages are completed, they will be interfaced with the visualization system.
4. Tracking algorithm: the tracking algorithm (Herrera-Rodriguez et al., 2015) will be implemented in python to identify and track pre-genesis cloud clusters
5. Intensity estimation: Using the DAV, an estimation of the intensity will be found according to a parametric curve and implemented in python
6. Wind field estimation: Using the DAV, the wind field algorithm (Dolling et al., 2016) will be implemented in python, validated against best track data and inserted into the visualization package.

The intensity algorithm requires the input of the DAV maps. The intensity is estimated using a parametric curve that relates tropical cyclone intensity with the p-pt DAV averaged over the centre of the tropical cyclone. The algorithm will differ with different sets of data points but generally the inputs are the DAV values, the centre location of the tropical cyclone, and the best-track intensity estimate to validate the DAV estimate in hindcast mode.

A brief breakdown of this full year project shows us that there are four main tasks including creating visualisations to process satellite imagery, calculating/computing the DAV, developing the tracking algorithm, and computing the intensity and the wind field algorithms. The main goal of this project would be to create a piece of software (web-app, package) that encapsulates these algorithms/calculations.

There are a few approaches we can take for this project in terms of software. We had the options of creating a web-based application or a python package. We decided it is best to opt for a python package which gives a visualisation of the tropical cyclone. What this package will allow researchers to do is effectively use these algorithms and view the visualisation to further enhance studies within the field of tropical cyclones and allow us to better analyse and understand the different properties of tropical cyclones. The purpose a python package serves is that it allows analysts/researchers to save time by allowing them to reuse the mentioned algorithms. This python-package is a gap we will fill within the study that has been done so far and it would greatly benefit researchers to be able to readily perform data analysis. Most importantly, it would help analysts and meteorologists best prepare for tropical cyclones and predict severity of them.

Previously, a student team created a web-based application, however the progress that they made has been lost. Therefore, this year, the work that we conduct will be completed and saved in a central repository and we will make sure that this repository is successfully shared with Monash before offboarding. In addition, the previous years' students did not implement all the algorithms.

The technical challenges that we might face within this project are mainly related to design of the python package and whether we can program the calculations/algorithms with the desired outputs/without any miscalculation and errors. An additional technical challenge we might face is dealing with the dataset. Not all team members have experience with image processing, and this can be challenge when attempting to process the satellite data/images. Further challenges/risks we might face are outlined in the risk assessment table.

4 Requirements, Specifications and Approach

4.1 Requirements

High level requirements

Requirement ID	Requirement Description
[H.001]	The software must perform Deviation Angle Variances (DAV) calculations from provided satellite infrared data and provide a visualization of the satellite and DAV maps.
[H.002]	The software must use the DAV maps to perform tropical cyclone intensity estimations
[H.003]	The software must use the DAV maps to do cyclone tracking
[H.004]	The software must use the DAV maps to perform two-dimensional wind field calculations

Financial requirements

Requirement ID	Requirement Description
[F.001]	In case we need to access data API, the cost should be no more than $100

Non-Functional requirements

Requirement ID	Requirement Description
[N.001]	The software must be developed in Python
[N.002]	The software must provide graphs of the algorithm results with validation
[N.003]	The software must provide visualization maps of the computations

4.2 Design specifications & Approach

To perform cyclone tracking, intensity, and wind field calculations we will use the computed DAV values. This will be done using python by utilizing its statistics code packages and visualization packages to display results on the graph. Satellite images of the tropical cyclone will be retrieved and processed for computing DAV values and using these for cyclone tracking, intensity, and wind field calculations.

The DAV values, will be computed from the infrared brightness temperature data in the North Atlantic basin (Piñeros et al. 2008, 2010, 2011).

For the tracking algorithm, we will create an algorithm based on Rodriguez-Herrera et al. (2015) that finds the initial position of tropical cyclone cloud clusters based on minimum values of the DAV and accounts for the movement of the storm, relevant factors, the DAV values. If there is time we will improve the tracking algorithm by incorporating other features, such as the cloud asymmetries to provide short-term tracking prediction.

For the cyclone intensity, we will create an algorithm using the DAV values clustered around the centre of the cyclone to estimate the storm's intensity (Piñeros et al., 2011).

For the cyclone's wind field, we will create an algorithm that will estimate the wind fields based on Dolling et al. (2016). DAV values from a computed map of variances will be used as a predictor in a multiple linear regression model along with environmental parameters from the SHIPS model and variables from the EBT data to estimate wind field parameters. This will be done for symmetric and asymmetric models of the wind fields, where the former azimuthally averages the DAV values for each radius along the extended best track (EBT) symmetric component using EBT centres, while the latter azimuthally averages the DAV values in four quadrants (northwest, northeast, southwest, southeast). For both models, the regression parameters (cyclone age, sea surface temperatures and intensity) are found to get the best results of the wind radii. (Dolling et al., 2016)

All the algorithms created will be integrated to their own visualizations, such as a graph, where the user can interact with them and control the data displayed.

5 Scope, Project Plan & Timeline

5.1 Project Scope

Deviation Angle Variance (DAV) computing:

a) Access and download reliable satellite infrared brightness temperature datasets at half-hourly resolution from NOAA for the North Atlantic for no more than one season. Ensure data quality and consistency across different datasets and time periods.
b) Downscale satellite images to 10-km pixel resolution to save computational time.
c) Compute DV maps for each satellite image.

Visualization of North Atlantic:

a) Develop a Python-based visualization infrastructure to display satellite imagery and DAV maps for the North Atlantic region, using libraries such as NumPy, Pandas, and Matplotlib.
b) Use the processed data to generate visualizations of storm patterns, intensity, and other relevant parameters, using tools such as Base map or Cartopy.

Tracking Algorithm - Cloud Clustering:

a) Develop a cloud tracking algorithm based on the DAV parameter to identify and track developing cyclones over time.
b) Develop a component in the visualization infrastructure to display the track positions and associated information.

c) Develop a linked database to store computed positions.

Intensity Algorithm:

a) Develop an intensity estimation algorithm using the averaged DAV values at the center of the cyclone based on the Piñeros parametric curve (Piñeros et al., 2011).
b) Validate the DAV-based intensity estimates against historical best track data.

The wind-field algorithm for estimating the wind field of storms based on radar data and storm parameters is considered as low priority in the current project. Although wind speed and central pressure are essential parameters in assessing the intensity of a storm, developing a separate algorithm for wind field estimation would require additional data parameters and statistical methods, which could be time-consuming and is not high priority at this stage of the project. Therefore, it will be considered as a low priority for the current project.

5.2 Project Plan & Timeline:

The team will be developing a Python-based infrastructure to process and analyse satellite imagery for tropical cyclones throughout the year. This is split across 2 projects.

Project A: Technical Research & Initial Delivery

1. Requirement elicitation & Theoretical Research
2. Initial product Development and delivery

Project B: Deployment, Testing & Maintenance Operation

3. Integration of algorithms into visualisations
4. Software testing & Deployment
5. Maintenance & Operation

All 5 phases at depth:

1. **Requirement elicitation & Theoretical Research**
   This is the initial phase of the project, where the requirements for the project are gathered, analysed, and documented. Theoretical research may also be conducted to determine the feasibility and potential solutions for the project.

   Sub-phases:
   a. Domain Analysis Discussion
   b. Research & Literature review
   c. Risk Management
   d. Project Proposal

   Domain Analysis & Theoretical Research

- A deeper understanding of the scientific principles that underlie tropical cyclone formation, evolution, and behaviour, such as the dynamics of the atmosphere and the ocean, the thermodynamics of heat and moisture exchange, and the interaction between different scales of motion.
- Exposure to different methods and approaches that researchers use to study tropical cyclones, such as numerical modelling, data analysis, remote sensing, field observations, and theoretical frameworks.
- Knowledge of the history and evolution of tropical cyclone research, including key discoveries, debates, controversies, and milestones, as well as the contributions of different disciplines, individuals, and institutions.
- Potential for identifying research questions and gaps that could inspire future research projects or collaborations, as well as potential for contributing to the advancement of knowledge and practice in the field of tropical cyclones.

Project proposal

- Derive a clear outline of the proposed project including objectives, goals, deliverables, timeline, and budget.
- Provide a clear and concise overview of the project to stakeholders and help ensure everyone involved is on the same page.
- Come up with a logical and appropriate timeline/roadmap for the project in which outlines the steps and activities that need to be completed to achieve the objectives and deliverables of the project.
- Provide a clear plan of action for the team to follow and helps ensure that the project stays on track and is completed within the allocated time and budget.

2. <u>Initial product Development and delivery</u>

In this phase, the actual development of the product takes place based on the requirements documented in the previous phase. This includes designing, coding, and creating the product. Once the product is completed, it is delivered to the stakeholders.

Sub-phases:

a. Technical Preparation 1 - git, branching, individual task allocations, Research & Literature review
b. DAV Computation
c. Tracking Algorithm
d. Intensity Algorithm
e. Technical Preparation 2 - frontend setup
f. Visualisation & Interface
g. Windfield Algorithm

Technical research

- Identify data parameters required for DAV computing, data visualization, tracking algorithm, intensity algorithm, and wind field algorithm. Identify reliable data sources for radar and satellite imagery data.
- Analysis of existing algorithms for detecting and tracking tropical cyclones from satellite imagery. Investigation of methods for calculating tropical cyclone properties such as intensity and wind speed from satellite data. Study of statistical models and machine learning techniques for probabilistic formation prediction.
- Choose a version control system (VCS), such as Git, to manage code changes and collaboration between team members. Decide on a hosting platform for your code repository, such as GitHub, GitLab, or Bitbucket.
- Set up a repository structure that makes sense for your project, including the organization of directories and files.
- Define a workflow for code reviews and pull requests to ensure that changes are reviewed and approved before being merged into the main codebase.
- Establish guidelines for documentation and code comments to ensure that the code is well-documented and easy to understand for future contributors.

Setting up the infrastructure.

- Setup the programming environment for the infrastructure development
- Develop the data processing pipeline for DAV computing

Deviation-Angle Variance computations

- Obtaining satellite imagery to grayscale infrared image of the tropical cyclone to determine the storm centre is based on the minimum temperature within a circular area around the centre of the image.
- The circular area is divided into 8 equal sectors, each covering 45 degrees of the circle.
- The temperature within each sector is averaged, and the deviation angle is calculated for each sector by subtracting the sector average from the temperature at the storm centre.
- The DAV is then calculated by taking the variance of the deviation angles from all 8 sectors.
- The resulting DAV value is used as an indicator of the strength and symmetry of the tropical cyclone. A higher DAV value indicates a more asymmetric cloud pattern, which is often associated with a weaker storm.

Developing Tracking Algorithm

- Retrieve the initial position of the storm center from the International Best Track Archive for Climate Stewardship (IBTrACS) (Data: IBTrACS track archive) tropical cyclone best track archive, which is a repository of all TC track positions globally.
- Identify the features of the storm that will be used for tracking, such as the location of the eye or the position of the heaviest rainfall.
- Develop a tracking algorithm that considers the movement of the storm and any other relevant factors, such as wind speed and direction.

- Use the tracking algorithm to estimate the future path of the storm based on its current trajectory and speed.
- Continuously update the position of the storm center as new data becomes available.
- Validate the tracking algorithm by comparing its predictions to actual storm movements over time.
- Adjust the algorithm as necessary based on feedback and new data.

Developing Intensity Algorithm

- Obtain satellite imagery of the storm in question, preferably in the visible or infrared bands.
- Identify the centre of the storm by locating the area of lowest cloudiness or the centre of the most intense convection.
- Analyse the cloud pattern surrounding the centre of the storm to determine the organization and symmetry of the storm's structure. This involves looking for features such as spiral banding, eye formation, and outflow.
- Use the Direct Angular Momentum Variation (DAV) method to estimate the storm's maximum sustained winds and central pressure, as described in *Pineros et al. 2011*. This method considers the storm's size, symmetry, and intensity, as well as environmental factors such as sea surface temperature and upper-level wind shear.
- Cross-check the DAV estimate with other available wind speed estimates, such as those derived from aircraft or buoy measurements, and adjust if necessary.

3. **Integration of algorithms into visualisations**

In this phase, the backend algorithms are implemented into visualizations to achieve better data analysis and interpretations of the data.

Integration of algorithms into visualisations

- Identify the type of visualizations that will be used to display the output of each algorithm. This could be a map, a graph, or some other type of visual representation.
- Determine the data formats that each algorithm produces as output. This will help identify how the output data can be integrated into the visualization.
- Develop a data pipeline that takes the output of each algorithm and transforms it into a format that can be easily integrated into the visualization.
- Develop a user interface that allows the user to interact with the visualization and control the display of the data.
- Test the integration of each algorithm into the visualization to ensure that it produces the expected output and that it is displayed correctly.
- Iterate on the integration process, refining the pipeline and user interface as needed based on user feedback.

4. **Software Testing & Deployment**

This phase involves testing the product to ensure that it meets the requirements and works as intended. This includes functional testing, performance testing, security testing (if required), and other types of testing to ensure the quality of the product. Once the testing is completed, the product is deployed to the production environment.

Sub-phases:

a. Testing Planning & Research
b. Bug Fixes
c. Deployment: Code freeze

Product Testing and Iteration

1. Define test cases: Identify a set of test cases to ensure that the system meets its functional and non-functional requirements.
2. Create a testing plan: Develop a testing plan that includes the test cases, testing procedures, and tools required for executing the tests.
3. Execute tests: Run the tests and record the results.
4. Debugging: Investigate and resolve any issues or bugs found during testing.
5. User testing: Conduct user testing to gather feedback and identify areas for improvement.
6. Incorporate feedback: Analyse user feedback and incorporate changes or improvements to the system.
7. Regression testing: Perform regression testing to ensure that the changes made do not introduce new issues or regressions.
8. Repeat: Continue the testing and iteration process until the system meets the desired level of quality and usability.

Polishing User Interfaces

1. Gather user feedback: Collect feedback from users on the current user interface, identify pain points, and determine areas for improvement.
2. Analyse user feedback: Analyse user feedback and identify common patterns or issues that need to be addressed.
3. Design improvements: Develop new design concepts or improve existing designs based on user feedback and best practices in user interface design.
4. Implement changes: Make necessary changes to the user interface based on the new design concepts or improvements.
5. Test changes: Conduct user testing to ensure that the changes made to the user interface are effective and intuitive.
6. Iterate: Continuously iterate on the design and gather feedback until the user interface is polished and meets the desired level of usability and user satisfaction.

Integration and Final Testing

- Integrate all the developed components of the infrastructure and test the end-to-end functionality
- Final Bug Fixes: Address any remaining issues or bugs identified during testing.

- Packaging and Deployment: Prepare the system for deployment by packaging it into a release candidate and creating installation packages.
- Monitoring and Maintenance: Establish a monitoring and maintenance plan to ensure that the system is functioning correctly and to address any issues that arise over time.

5. **<u>Maintenance & Operation</u>**
The final phase of the project is the maintenance and operation phase, which involves ongoing maintenance and support of the product after it has been deployed. This includes fixing bugs, providing updates, and addressing any issues that arise in the product during its use. It also includes ongoing operational support for the product, such as user training and documentation.

Documentation and Deliverables

- Document the codebase and instructions for running the infrastructure
- Maintaining documentation: Update and maintain documentation as necessary, such as when new features or functionality are added to the system.
- Archiving documentation: Archive documentation for future reference or reuse.
- Finalize the project deliverables and submit the final report

Review and Submission

- Review the project and make any final revisions
- Submit the project and deliverables

Project Roadmap: Tropical Cyclones 2023

The above visual represents a draft project roadmap/timeline. Please note this timeline is simply an estimation and is due to change throughout the progression of this project.

5.3 Work Breakdown

Please refer to the team contract document attached to the end of this proposal document.

Here is a summary of the roles:

Siva Thangavel – Product Owner

Shakthi Champak – Release Train Engineer

Ahmed Ateeq – Frontend Lead

Jason Tay – System Architect

Rahik Sayed – Backend Lead

Please note, all members in the team will be equally involved in all phases of the project in terms of programming and product development. These roles are simply an area of additional tasks each member will be responsible for.

6 Risk Management Plan

6.1 Risks:

The risks involved in this project will include OHS risks and non-OHS risks, where the latter is associated with the nature of the data we are using, the external factors that may need to be accounted for in our data and the effectiveness of our project completion. The OHS risks involved are associated with ergonomic use of computers and handling of electrical equipment and are referenced in our OHS risk assessment document. Our non-OHS risks are placed in a risk table, where each of them will have the likelihood, consequence and risk level ratings shown below.

Consequence and Likelihood	Insignificant	Minor	Serious	Disastrous	Catastrophic
Rare	L	L	L	L	M
Unlikely	L	L	M	M	S
Possible	L	M	M	S	H
Likely	L	M	S	H	E
Almost Certain	M	S	H	E	E

Where L=Low Risk, M=Medium Risk, S=Substantial Risk, H=High Risk, E=Extreme Risk.

6.2 Risk Assessment Table

Project Risk	Risk	Likelihood	Consequence	Risk level	Mitigation	Residual Risk
Delayed completion of DAV (Deviation Angle Variance) computing	Inability to complete other tasks of the project	Possible	Serious	M	Make up or use dummy data of DAV for use of other tasks. Start coding the other tasks first while completing the DAV task	Difficult to test other tasks without completion of the DAV computing task Even if we played with dummy DAV data, we might not get the desired results when testing our code
Unsuitable collected data	Unable to use data to complete our tasks	Unlikely	Serious	M	Check over the data attributes, such as looking at the CSV columns, to see if they can be used for our tasks	Checking for the suitability of data could be time consuming due to many datasets to potentially check
Data unavailability	Unable to retrieve cyclone	Unlikely	Serious	M	Check the authenticity of the data before using it.	

	data for our algorithms					
Lack of computational power	Inaccuracies from our computing algorithms	Unlikely	Minor	L		
Climate change	Could cause inaccuracy of our algorithms if not accounted for	Possible	Minor	M	Data on climate change could be collected to give account for	
External weather factors	Other factors can affect the cyclone weather which may not be accounted for	Possible	Minor	M	Could try to collect other weather data to take account for	Collecting such data may cause this project to become too complex to complete as we have to account for many factors

6.3 OHS Risks

Refer to appendix A.

7 References

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8 Appendices:

8.1 Appendix A: Project Risk Assessment

MONASH University

1. Activity or Task Based Risk Assessment [Ref Number: 46245]

		Current Rating	Residual Rating
Name	Analyze tropical cyclone properties from satellite imagery	Medium	Medium
Location	Clayton - 14 Alliance Lane - Engineering 72 (72) - Level 02 - 210		

Business Unit	Last Review Date	Risk Owner
Dean Faculty of Engineering	17/03/2023	JASON PHUONG TAY

Risk Assessment Team	Risk Approver
SIVASUBRAMANIAN GAYATHRI THANGAVEL (Student) SHAKTHI PRASHANTH CHAMPAKA (Student) RAHIK AHMED SAYED (Student) AHMED ATEEQ (Student)	Elizabeth Ann Ritchie-Tyo

Additional Notes

Describe task / use
Analysing tropical cyclone data

MONASH University

1. Activity or Task Based Risk Assessment [Ref Number: 46245]

Risk Factors

Risk Factor	4.3 - Musculoskeletal stress from awkward posture or repetitive movements

Description	
Risk of muscle pain or long hours of working on the computer	• 1.0 - Fixed plant (e.g. cool rooms, fume cupboards, safety showers, boilers, lathes, lifts, gas mains, PET scanners) -- No • 2.0 - Transport and mobile plant (e.g. motor vehicles, forklifts, walky stackers, trolleys and wheelbarrows) -- No • 3.0 - Powered equipment, tools and appliances (e.g. computers, workshop equipment, kitchen equipment, gas cylinders) -- No • 4.0 - Non-powered handtools and equipment (e.g. furniture and fittings, ladders, handtools, packing equipment, glassware) -- No • 5.0 - Chemical materials (e.g. dangerous goods, hazardous substances, poisons and drugs) -- No • 6.0 - Materials and substances (not otherwise selected from category 5.0) -- No • 6.3 - Fire and smoke -- No • 7.1 - Outdoor working environment (e.g. carparks, walkways, outdoor stairs) -- No • 7.2 - Indoor working environment (e.g. internal rooms, floor surfaces, stairwells) -- Yes • 8.5 - Biological materials (e.g. animals, non-living animal materials, microorganisms) -- No • 8.4 - Personal impairment and/or interaction (e.g. pre-existing medical condition, assisting a patient) -- No • 9.1 - Psychological (e.g. stressful situations) -- No

Low	Low
Existing Controls	**Proposed Controls**
• 4 - Engineering control measure: Use an adjustable ergonomic chair. • 5 - Administrative control measures: Take breaks from sitting on the chair. Do some stretches.	

Risk Factor	5.7 - Electricity

Description	
Risk of electric shock from electrical equipment.	• 1.0 - Fixed plant (e.g. cool rooms, fume cupboards, safety showers, boilers, lathes, lifts, gas mains, PET scanners) -- No • 2.0 - Transport and mobile plant (e.g. motor vehicles, forklifts, walky stackers, trolleys and wheelbarrows) -- No • 3.0 - Powered equipment, tools and appliances (e.g. computers, workshop equipment, kitchen equipment, gas cylinders) -- Yes • 4.0 - Non-powered handtools and equipment (e.g. furniture and fittings, ladders, handtools, packing equipment, glassware) -- No • 5.0 - Chemical materials (e.g. dangerous goods, hazardous substances, poisons and drugs) -- No • 6.0 - Materials and substances (not otherwise selected from category 5.0) -- No • 6.3 - Fire and smoke -- No • 7.1 - Outdoor working environment (e.g. carparks, walkways, outdoor stairs) -- No • 7.2 - Indoor working environment (e.g. internal rooms, floor surfaces, stairwells) -- No • 8.5 - Biological materials (e.g. animals, non-living animal materials, microorganisms) -- No • 8.4 - Personal impairment and/or interaction (e.g. pre-existing medical condition, assisting a patient) -- No • 9.1 - Psychological (e.g. stressful situations) -- No

Medium	Medium
Existing Controls	**Proposed Controls**
• 5 - Administrative control measures: Keep liquids away from electrical equipment. Make sure that all electrical equipment being used are in good condition and that they have up to date tags on them, to ensure they have been tested too.	

Appendix

Documents Referenced
https://www.monash.edu/ohs/info-docs/ergonomics for ergonomic principles for working with computers.

Risk Matrix Level	
Negligible	No additional control measures required
Low	Manage by routine procedures at local management level
Medium	Management responsibility must be specified and response procedures monitored
High	Senior management attention needed and management responsibility specified
Extreme	Immediate action required and must be managed by senior management with a detailed plan

8.2 Appendix B: Team Contract

Team Contract

Teams are responsible to fill out any and all areas of the contract in blue below.

Team Name: FYP – Cyclone Analysts

Team Member Names:

Siva Thangavel - 31500234	Rahik Ahmed Sayed - 29699460
Shakthi Prashanth Champaka - 31215181	Ahmed Ateeq - 30628377
Jason Tay - 30586526	

1. Document Purpose

The purpose of this team contract is to outline the standard operating practices and team norms of the above-named team and individually listed members for the remaining duration of the team lifespan. The guidelines outlined in this document are agreed to by all team members as indicated by their signature at the end of the contract. Any amendments to the contract must be discussed and agreed to by all signing members. Failure to abide by the outlined standard operating practices of this contract could harm the team's overall functioning and result in penalizing action as detailed in the contract.

2. Rules and Regulations

The team agrees to the following guidelines regarding general procedures, practices, and behaviours that are deemed acceptable.

A) Expectations

i. Project Expectations

- Develop a robust and scalable python-based satellite imagery visualization infrastructure for processing, analysing, and displaying tropical cyclone properties.
- The code should be well-documented, modular, and adhere to best practices.
- The outputs and visualizations should be accurate and reproducible.
- The software should be user-friendly and open-sourced to researchers.
- The final deliverable should be a python package that includes all the developed modules.
- The package should include detailed documentation and instructions on how to use it.
- The package should be tested and validated on historical data for different tropical cyclones.
- The team will set overall project deadlines together and establish individual milestones and self-imposed deadlines. (Discussed further in the project timeline & Roadmap)
- The team will communicate regularly to ensure that everyone is on track and to discuss any challenges that arise.

- The team will regularly evaluate progress and contribution to ensure equal distribution of workload. In case of any inequality in contribution, the team will discuss and identify potential solutions along with advise from the assigned supervisor.

ii.Member Expectations

- Each member is expected to contribute equally to the project and complete assigned tasks on time.
- Each member should demonstrate attention to detail, accuracy, and commitment to quality.
- Each member is encouraged to contribute ideas and actively participate in discussions.
- The expected weekly time commitment for each member may vary based on their role and responsibilities within the project. However, a minimum commitment of 5-10 hours per week is expected from each member to ensure timely progress.
- All team members are expected to adhere to Monash University's academic integrity and honesty policies.
- All sources of information and data used in the project should be properly cited and referenced.

iii.Role Expectations

- Product Manager – Siva Thangavel
    - The project manager should develop a project plan that outlines project goals, milestones, timelines, and budget, and ensure that the team adheres to it.
    - The project manager should oversee the work of all team members, ensure that they are working effectively and efficiently, and provide support and guidance as needed.
- Release Train Engineer – Shakthi Champaka
    - The RTE should facilitate the planning and coordination of the project across multiple teams and stakeholders.
    - The RTE should work closely with the Product Owner to develop and prioritize the product backlog and ensure that it aligns with the project goals and objectives.
- System Architect – Jason Tay
    - A System Architect should have a deep understanding of software and system design and development, and should have expertise in a range of relevant technologies and programming languages.
    - The System Architect should be able to provide guidance and support to the development team, including advising on the selection of technologies and tools, and designing scalable and efficient solutions.
- Backend Lead – Rahik Ahmed Sayed
    - The Backend Lead should have a strong technical background and be knowledgeable in backend technologies such as server-side

    programming languages (e.g. Python), databases, APIs, and web servers.
  - The Backend Lead should be able to provide technical guidance and support to the team, identify and solve technical problems, and design scalable and efficient solutions.
- Frontend Lead – Ahmed Ateeq
  - The Frontend Lead should be able to provide guidance and support to the development team, including advising on the selection of technologies and tools, and designing scalable and efficient solutions for the frontend of the application.

B) Communication

i. Communication Medium

- Microsoft Team will be the primary formal communication medium amongst the Team members and supervisors.
- Team Members may choose to contact on Teams or a preferred medium of common usage.

ii. Communication Timelines

- Communication to the supervisor must strictly be within teaching hours (9am-5pm weekdays).
- Communication amongst team members may vary depending on the commitments of each of the team members.

iii. Communication Code of Conduct

- All team members should communicate with each other in a respectful and professional manner. Team members should avoid using offensive language, making personal attacks, or belittling others.
- When communicating with others, team members should actively listen to their concerns, ideas, and feedback. Team members should ask questions to clarify understanding and seek feedback to ensure that they have understood the message correctly.

C) Team Meetings

i. Scheduling

- Scheduling of meetings with the supervisor must atleast be 3 business days prior to the request of the meeting and within weekday teaching hours (9am-5pm).
- Scheduling of meetings amongst team members may vary depending on the schedules of each of the team members.

ii. Involvement

- Detail how the team will ensure all team members are involved in team meeting discussions and decisions.
- Outline the expectation of team members in regards to preparation for team meetings.

iii. Attendance & Notice

- It is expected that all team members will make all the meetings once accepted the meeting invite from the organizer.
- If unable to attend the meeting, it is necessary to advise the team at least 12 hours before the meeting takes place.

D) Team Conflict & Decision Making

i. Conflict Code of Conduct

- All team members are expected to respect each other's opinions and perspectives, even when they disagree. Personal attacks, insults, or belittling behaviour will not be tolerated.
- All team members are expected to communicate constructively, using "I" statements, avoiding blame or accusations, and focusing on finding solutions. Aggressive or passive-aggressive communication, sarcasm, or defensiveness are not allowed.

ii. Initial Conflict & Conflict Escalation

- The team member should address the conflict directly with the person or people involved in a respectful and professional manner.
- The team member should actively listen to the other person's perspective, seeking to understand their point of view, and asking clarifying questions when necessary.
- The team member should work with the other person to find a mutually agreeable solution to the conflict.

iii. Decision-Making

- The team will first discuss the options and evaluate each one based on the project's goals and requirements. Each team member will have an opportunity to express their opinions and provide their reasoning for their preferred option.

E) Stress Management

i. Monitoring & Assistance

- Team members should feel comfortable talking about their workload and stress levels with each other. Encourage them to speak up if they are feeling overwhelmed or need help.
- Team members can offer support to each other in a variety of ways, such as by sharing resources, offering to take on some tasks, or simply providing a listening ear.

F) Contract Code of Conduct

i. Contract Breaches

- Any breaches of the contract will be notified to the supervisor who may take appropriate action.

ii. Penalties

- Penalties will be discussed with the supervisor or unit coordinator to receive appropriate remedies.

3. Declaration

By signing below, team members acknowledge and agree to be bound by the guidelines outlined above.

Siva Thangavel	04-04-2023
Team Member Signature	Date
Ahmed Ateeq	04-04-2023
Team Member Signature	Date
Jason Tay	04-04-2023
Team Member Signature	Date
Shakthi Prashanth Champaka	04-04-2023
Team Member Signature	Date
Rahik Sayed	04-04-2023
Team Member Signature	Date