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HARMONIZED CURRICULA FOR THE GR2A MASTERS PROGRAMMES- ICTs AND CLIMATE CHANGE

By

Intra-African Mobility-Gr2A Project Consortium

- The Copperbelt University -Zambia
- Rhodes University- South Africa
- University of Eswatini -Eswatini
- NUST Namibia -Namibia
- NUST Zimbabwe -Zimbabwe
- University of Turku -Finland





CONSORTIUM CURRICULUM IN ICT (CLIMATE CHANGE)

By

**Intra-African Mobility Project Consortium
(Rhodes University- South Africa, University of Eswatini -Eswatini, NUST Namibia
-Namibia, NUST Zimbabwe -Zimbabwe, The Copperbelt University -Zambia, University of
Turku -Finland)**

1. Introduction

Most African Universities are experiencing a scarcity of trained personnel who can support the climate change agenda at National and Regional levels and who can work towards the development of innovative green solutions that are of relevance, focusing on sustainability. In order to successfully combat future challenges such as a climate-unstable future, knowledge sharing is very crucial.

This NDICI-2023-MOBAF-Intra-Africa Academic Mobility Scheme is very timely to help the African nations to play a collaborative role through higher education, research and training to build a critical mass of African scientists and engineers who can develop Climate Smart solutions. Understanding of climate change research and green computing education can prepare African youth for green industries. By nurturing their skills in 4IR technologies such as Internet of things, Artificial Intelligence and machine learning, energy-efficient software development, and renewable energy integration, Africa can build a workforce that drives the green economy while advancing environmental sustainability.

This outcome-based education can be achieved through better collaboration among regional universities and therefore a consortium of Education Institutions of Higher Learning in Southern Africa has come forward to put forward this proposal 'Grow Green Africa (Gr2A): A Capacity building initiative for Climate Change Resilience using Smart Green Technologies' to seek the



support under the NDICI-2023-MOBAF Intra-Africa Academic Mobility Scheme. Institutions in the Consortium are: the Copperbelt University of Zambia; National University of Science and Technology (NUST), Zimbabwe; Namibia University of University and Technology, Namibia; Rhodes University and University of Swaziland. By equipping students with the knowledge and skills needed to adopt eco-friendly computing practices, Africa can reduce its ecological footprint, mitigate climate change, create employment opportunities, and enhance its global competitiveness. Embracing green computing education is not only essential for the environment but also for achieving long-term socioeconomic progress on the continent.

Therefore, the overall objective of this project is to increase skills and qualifications of the youth across the African continent who can develop Climate Smart solutions. Understanding of climate change research and green computing education can prepare African youth for a sustainable climate smart future.

2. Aims and Specific Objectives

To meet its general objective, the Grow Green Africa (Gr2A) project identifies and addresses specific needs and objectives with clearly measured indicators for achievement.

This document is aimed at addressing need one (1) as indicated in the Partnership Agreement, which is 'to reinforce the capacity of the South African regional Universities to train the youth in Green computing and 4IR technologies to develop Climate Smart solutions'.

3. General Objectives

The objectives are drawn from specific objective 1.1: Update the curriculum of the identified Masters and PhD in ICT programmes among the consortium members to include courses/modules related to climate change mitigation with 4IR technologies and green computing.

4. Target Group

Students are selected from the following 2 groups:

1. Applicants must be registered or admitted in or having obtained a HEI degree or equivalent from one of the HEIs listed as Consortium partners. (**Group 1**):
 - Copperbelt University of Zambia (CBU), Zambia
 - National University of Science and Technology (NUST), Zimbabwe;



- Namibia University of Science and Technology (NUST), Namibia;
- Rhodes University (RU), South Africa
- University of Eswatini (UNESWA), Eswatini

2. Applicants must be registered or admitted in or having obtained a HEI degree or equivalent from any HEI not included in the partnership as a partner but established in an eligible country. (**Group 2**)

4. Proposed Curriculum

A Consortium curriculum has been considered covering the following modules/courses with respect to their study programmes offered by consortium members.

1. Introduction to Climate Science
2. Applied Internet of Things
3. Machine learning
4. Applied data science
5. Climate Modeling

The following is the harmonized content:



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Title: Introduction to Climate Science

Preamble

Climate change is one of the most pressing issues of our time, influencing ecosystems, weather patterns, sea levels, and global economies. This course delves into the scientific principles that underlie climate change, including the greenhouse effect, atmospheric dynamics, and the carbon cycle. The course explores the historical climate variations, current trends, and projections for future climate scenarios to give students a comprehensive and fundamental understanding of the science behind climate change. In this era of unprecedented environmental challenges, grasping the complex interplay between human activities and the Earth's climate system is crucial. This course will equip students with the scientific knowledge and analytical tools necessary to comprehend the mechanisms driving climate change and critically evaluate these changes' impact on the natural, social, economic, and other human systems.

Course Duration: 1 Semester

Credits/ Hours: To be determined by individual institutions

Prerequisite: None

Course Objectives:

- To understand the causes and effects of climate change;
 - Computing - Energy consumption, Carbon Footprint, E-waste, Resource Depletion, Heat Emissions
- ·To understand the various global, regional, and national efforts being employed to mitigate and or adapt to climate change;
 - Computing - Component Sourcing, Energy Efficiency, Sustainable Hardware, Green coding, Circular Economy
- Be able to describe major aspects of local, regional, and global climate change, climatology and meteorology, biosphere systems, and how these affect the environment and society; and Prepare students to be able to analyze climate data from various sources, including satellite observations and climate models.



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Course Outcomes:

- Gain a solid grounding of the Scientific Basis of Climate Change and have a detailed understanding of the physical principles and processes that govern climate systems;
- Assess and evaluate the impacts on natural and human systems and explore strategies for mitigation and adaptation impacts of climate change;
- Be able to design and implement mitigation and adaptation strategies;
- Communicate Climate Science: Develop the ability to effectively communicate complex climate science concepts to diverse audiences.

Content:

1. Climate Change as a Global Issue
 - a. The Earth's climate mechanism and feedbacks
 - b. The physical science basis (meteorology versus climatology)
 - c. Climate change attribution, and showcasing the evidence
2. Data Acquisition Technologies in Climate Science
 - a. Ice core
 - b. Luminescence
 - c. Ground weather stations
 - d. Remotely sensed (Satellites and Radiosondes)
 - e. Dendroclimatology
3. Atmospheric Physics and Climate Systems
 - a. Temperature profile
 - b. Thermodynamics, energy balance, and fluid mechanics,
 - c. Air masses, heat transfer, pressure systems, and boundary layer
 - d. Climate system classification (Temperature Precipitation vs. evaporation)
4. Climate Change Mitigation and Adaptation focus on the extractive industry
 - a. Geo-engineering the earth's climate system: Ethics and sustainability aspects
 - b. Nature-based solutions
 - c. Climate Policy Interface

Assessment

- Continuous Assessment: 50%
- Sessional Exam: 50%

Prescribed Readings

- Engelbrecht, F.A., Steinkopf, J., Padavatan, J., Midgley, G.F. 2024. Projections of Future Climate Change in Southern Africa and the Potential for Regional Tipping Points. In: von Maltitz, G.P., et al. Sustainability of Southern African Ecosystems under Global Change. Ecological Studies, vol 248. Springer, Cham. https://doi.org/10.1007/978-3-031-10948-5_7
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- Barnard, S., & Elliott, M. (2015). The 10-tenets of adaptive management and sustainability: An holistic framework for understanding and managing the socio-ecological system. *Environmental Science and Policy*, 51, 181–191. <https://doi.org/10.1016/j.envsci.2015.04.008>
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Tools

Microsoft Office Package



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Title: Applied Internet of Things

Preamble

In response to the pressing global challenge of climate change, integrating Internet of Things (IoT) technology has emerged as a critical tool for monitoring, mitigating, and adapting to environmental shifts. This course introduces students to the principles and methodologies of leveraging IoT solutions to address climate change. Students will comprehensively understand IoT technologies, their applications in environmental monitoring and sustainability practices, and the broader societal impact. This course prepares students to comprehend the intricate interplay between technology and the environment and equips them with practical skills to develop impactful IoT solutions for a more resilient future.

Duration

The course can be taught over one semester.

Credits/Hours

To be determined by individual institutions

Prerequisites

The candidate should have basic computer programming, statistics, networking and hardware infrastructure knowledge.

Course objectives

The course objectives are to:

- Understand the theoretical foundations and significance of the Internet of Things.
- Understand the building blocks of the Internet of Things and its characteristics.
- Discuss the architecture, operation, and benefits of an IoT solution.
- Explore the relationship between IoT, Edge, fog, cloud computing, and big data.
- Apply IoT concepts to monitoring, mitigation, and adaptation to climate change.

Outcomes

- Able to understand the principles of IoT technology and its applications in climate change mitigation and adaptation.
- Able to analyze how IoT technologies can be used to monitor and address environmental challenges related to climate change.
- Able to explain the importance of data management and analytics (cloud computing, big data) for environmental data collected through IoT.
- Able to design and implement using IoT hardware and software for sustainable IoT solutions for monitoring and managing environmental parameters.
- Able to discuss the role of IoT in applications like green agriculture, responsible mining, renewable energy, groundwater management, and weather prediction.
- Able to recognise the ethical considerations surrounding data security and privacy in the context of IoT-based environmental monitoring.

Course Content

1. Introduction to Climate Change and IoT
 - Explore the fundamental concepts of climate change, its causes and impacts, and technology's role in mitigating its effects.
 - Explore the fundamental concepts of how 4IR technologies support green computing.
2. IoT device architecture and networks
 - Explore different types of sensors used in environmental monitoring, such as temperature sensors, humidity sensors, quality sensors, etc
 - Devices: IoT Device architecture and programming. Wireless and Wired IoT infrastructure. Cloud IoT infrastructure.
3. IoT Software
4. IoT platforms and Protocols
 - Introduce students to IoT platforms and protocols commonly used, such as MQTT, CoAP, LoRaWAN etc. Discuss their advantages, limitations, and suitability for different applications.
5. IoT lifecycle and Visualisation
 - Understanding IoT systems: A lifecycle approach, collect, communicate, analyze and act. Graphical representation of data collected from IoT devices and systems.
6. Energy Efficiency in IoT Systems
 - Explore methods for optimizing energy consumption in IoT devices using harvesting techniques to reduce their carbon footprint. Discuss techniques such as sleep modes, duty cycling, and energy-efficient communication protocols.
 - IoT Applications for Climate-Resilient Environmental Management



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- This topic explores how IoT technologies can enhance environmental resilience in the face of climate change. Participants will investigate IoT applications spanning green agriculture, responsible mining, renewable energy, groundwater management, and weather prediction. Through case studies, participants will learn to optimize resource usage, monitor environmental conditions, and mitigate climate-related risks, fostering sustainability across diverse sectors.
7. Data Management and Analytics for Sustainability
 - Cloud, Fog, Edge Computing and Big Data: storing, processing, and analyzing environmental data. Machine Learning and AI: applications in predictive maintenance, anomaly detection, and resource forecasting. Data Security and Privacy: ethical considerations in environmental data collection.
 8. The Future of IoT and Climate Action
 - Emerging Technologies: 5G, blockchain, and their role in IoT for sustainability. Policy and Governance: regulations for responsible use of IoT in environmental applications. Building a Sustainable Future: integrating IoT into broader climate change solutions.

Assessment

- Continuous Assessment 50%
- Final Exams 50%

Prescribed Textbooks

- Simone Cirani, Gianluigi Ferrari, Marco Picone, Luca Veltri. Internet of Things: Architectures, Protocols and Standards. Wiley, 2019. p.383. ISBN 9781119359678.
- Perry Xiao. Designing Embedded Systems and the Internet of Things (IoT) with the ARM® Mbed™. Wiley, 2019. p.316. ISBN 9781119363996.

Recommended Textbooks

- Getting Started with Atmel Studio 7. User Guide DS-50002712A. © 2018 Microchip Technology Inc. Access for free: .
<https://ww1.microchip.com/downloads/en/DeviceDoc/Getting-Started-with-Atmel-Studio7.pdf>



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Recommended Tools

- Arduino /Raspberry PI
- Apache Netbeans
- Kinoma
- Wireshark
- Mainspring
- Node-RED
- ThingsBoard IoT



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TITLE: MACHINE LEARNING

PREAMBLE:

This course is designed to give students a basic understanding of machine learning. The course will equip students with the knowledge and skills necessary to apply cutting-edge machine learning algorithms to tackle climate change challenges effectively. The students get practice in selecting and applying these algorithms, and evaluating and interpreting the results. Climate change is one of the most pressing challenges of our time, with far-reaching implications for the environment, society, and the global economy. As the world grapples with the complexities of climate dynamics, there is an increasing recognition of the pivotal role that advanced technologies, particularly machine learning, can play in understanding, mitigating, and adapting to these changes.

Duration

One Semester

Credits/Hours

To be determined by individual institutions

Prerequisite(s)

1. Basic understanding of statistics and probability
2. Introductory programming skills (Python recommended)
3. Familiarity with climate science concepts (recommended but not mandatory)

Course Objectives

This course is designed to provide a student with a comprehensive understanding of how machine learning techniques can be leveraged to address various aspects of climate change research, from predicting future climate trends to optimizing mitigation strategies and enhancing resilience.

Learning Outcomes

At the end of this course students should be able to:



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- Understand the fundamentals of machine learning.
- Apply machine learning techniques to climate change data and problems.
- Develop and implement ML models for predicting climate patterns and impacts.
- Evaluate the effectiveness of ML solutions in addressing climate change issues.

Course Content

- I. Fundamentals of Machine Learning
 - The Machine Learning Landscape
 - What Is Machine Learning?
 - Why Use Machine Learning?
 - Types of Machine Learning Systems
 - Main Challenges of Machine Learning
 - Testing and Validating
1. End-to-End Machine Learning Project
 - Working with Real Data
 - Looking at the Big Picture
 - Get the Data
 - Discover and Visualize the Data to Gain Insights
 - Prepare the Data for Machine Learning Algorithms
 - Select and Train a Model
 - Fine-Tune a Model
 - Launch, Monitor, and Maintain a System
2. Classification
 - Training a Binary Classifier
 - Performance Measures
 - Multiclass Classification
 - Error Analysis
 - Multilabel Classification
 - Multi Output Classification
3. Training Models
 - Linear Regression
 - Gradient Descent
 - Polynomial Regression
 - Learning Curves
 - Regularized Linear Models
 - Logistic Regression
4. Support Vector Machines
 - Linear SVM Classification
 - Nonlinear SVM Classification
 - SVM Regression



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- How SVMs make predictions and their training algorithms
5. Decision Trees
 - Training and Visualizing a Decision Tree
 - Making Predictions
 - Estimating Class Probabilities
 - The CART Training Algorithm
 - Computational Complexity
 - Gini Impurity or Entropy?
 - Regularization Hyperparameters
 - Regression
 - Instability
 6. Ensemble Learning and Random Forests
 - Voting Classifiers
 - Bagging and Pasting
 - Random Patches and Random Subspaces
 - Random Forests
 - Boosting
 - Stacking
 7. Dimensionality Reduction
 - The Curse of Dimensionality
 - Main Approaches for Dimensionality Reduction
 - PCA
 - Kernel PCA
 - LLE
 - Other Dimensionality Reduction Techniques
 8. Unsupervised Learning Techniques
 - Clustering
 - Gaussian Mixtures
 - I. Neural Networks and Deep Learning
 1. Introduction to Artificial Neural Networks
 - From Biological to Artificial Neurons
 - Implementing Multi-Layer Perceptrons
 - Fine-Tuning Neural Network Hyperparameters
 2. Training Deep Neural Networks
 - Vanishing/Exploding Gradients Problems
 - Reusing Pretrained Layers
 - Faster Optimizers
 - Avoiding Overfitting Through Regularization
 3. Deep Computer Vision Using Convolutional Neural Networks
 - The Architecture of the Visual Cortex
 - Convolutional Layer
 4. Pooling



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- CNN Architectures
- Implementing a ResNet
- CNN Using Keras
- Using Pretrained Models
- Pretrained Models for Transfer Learning
- Classification and Localization
- Object Detection
- Semantic Segmentation

Assessment

- Continuous Assessment 50%
- Final Exams 50%

Prescribed Reading

- Géron, A., 2022. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow. "O'Reilly Media, Inc."

Recommended Reading

- Bishop, C.M., 2006. Pattern recognition and machine learning. Springer
- Ian Goodfellow and Yoshua Bengio and Aaron Courville, 2016. Deep learning: The MIT Press
- Research papers and articles on ML applications in climate science
- Chollet, F., 2021. Deep learning with Python. Simon and Schuster.

Tools

1. Tensorflow
2. Pytorch
3. Keras
4. Jupyter Notebooks
5. Visual Studio Code
6. Google CoLab



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Module Title: Applied Data Science

Preamble:

This module provides participants with a comprehensive understanding of applied data science techniques and their practical applications in climate-related challenges. Participants will gain hands-on experience in data collection, preprocessing, analysis, modeling, and visualization, enabling them to extract valuable insights from diverse datasets. The module emphasizes real-world applications of data science, covering a wide range of climate-related applications such as modeling underground water supplies, renewable energy, weather pattern detection and prediction, green computing, green agriculture, and green mining technologies, among others.

Duration:

A total of 15-16 weeks (can be adjusted based on available time and depth of coverage), 4 hrs per week (2hrs theory/lectures, 2hrs practical/lab sessions)

Credits/Hours:

To be determined by individual institutions

Prerequisites:

- Basic knowledge of statistics and programming
- Familiarity with environmental/climate science concepts is beneficial but not mandatory

Course Objectives:

- To understand the fundamentals of data science and its applications in climate-related domains.



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- To develop skills in data collection, preprocessing, and analysis.
- To apply machine learning and statistical techniques to model and predict climatic and environmental phenomena.
- To explore data-driven solutions for sustainable development and climate change.
- To work with real-world datasets to solve practical problems in climate-related domains.

Learning Outcomes:

By the end of the course, students will be able to:

1. Explain the principles of data science and its significance in environmental and climate applications.
2. Collect, preprocess, and analyze data from various sources.
3. Build and evaluate predictive models for environmental and climate data.
4. Develop data-driven strategies for sustainable development.
5. Communicate findings and insights effectively using data visualization techniques.

Module Outline:

1. Introduction to Applied Data Science
 - Overview of data science and its applications in climate-related real-world scenarios
 - Understanding the data science workflow and its components
2. Data Collection and Preprocessing
 - Techniques for collecting and acquiring data from various sources
 - Data cleaning, transformation, and handling missing values
 - Exploring data quality and addressing data anomalies
3. Exploratory Data Analysis and Visualization
 - Statistical analysis techniques for exploring datasets
 - Data visualization methods for effective data exploration
 - Identifying patterns, correlations, and outliers in data
4. Regression Analysis and Predictive Modeling
 - Introduction to regression analysis and its climate-related applications
 - Building and evaluating predictive models using regression algorithms
 - Feature selection and model validation techniques
5. Classification and Decision Trees
 - Understanding classification problems and algorithms
 - Decision trees and ensemble methods (e.g., random forests)

- Evaluating and interpreting classification models
- 6. Unsupervised Learning: Clustering and Dimensionality Reduction
 - Clustering techniques for unsupervised learning
 - Dimensionality reduction methods (e.g., PCA) for feature extraction
 - Applications of unsupervised learning in climate-related real-world scenarios
- 7. Natural Language Processing (NLP)
 - Introduction to NLP and its applications
 - Text preprocessing, feature engineering, and sentiment analysis
 - Building NLP models for tasks like text classification or topic modeling
- 8. Time Series Analysis and Forecasting
 - Understanding time series data and its characteristics
 - Techniques for time series analysis, trend detection, and seasonality
 - Forecasting methods (e.g., ARIMA, exponential smoothing) for time series data
- 9. Big Data Analytics and Scalable Data Processing
 - Introduction to big data concepts and challenges
 - Distributed computing frameworks (e.g., Apache Spark) for big data processing
 - Scaling data science workflows and handling large-scale datasets
- 10. Ethical Considerations in Applied Data Science
 - Ethical considerations in data collection, usage, and privacy
 - Responsible data handling and bias mitigation
 - Ensuring fairness and transparency in data-driven decision-making
- 11. Case Studies and Real-World Applications
 - Case studies showcasing the application of data science in addressing climate-related challenges such as modeling underground water supplies, renewable energy, weather pattern detection and prediction, green computing, green agriculture, and green mining technologies.
 - Analyzing real-world datasets and deriving actionable insights
 - Group discussions and presentations on data science projects or applications
- 12. Future Trends and Emerging Technologies
 - Overview of emerging trends and technologies in data science
 - Introduction to advanced topics such as deep learning, reinforcement learning, and AI applications
- 13. Capstone Project
 - Participants will work on a hands-on capstone project that applies data science techniques to solve real-world climate-related problems or analyze complex datasets. This project will allow participants to showcase their skills and understanding of the concepts covered in the module.

Assessment Methods:

Weekly assignments and quizzes



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- Midterm exam
- Group project and presentation
- Final exam

Prescribed Readings:

- "The Power of Data: Driving Climate Change with Data Science and Artificial Intelligence Innovations" by Aboul Ella Hassanien, Ashraf Darwish.

Recommended Readings:

- "Data Science for Environmental Applications" by Amy Langville and Carl Meyer.
- "Introduction to Environmental Data Science" by Carleton R. Jones.

Tools:

- R/R-Instat
- Python (Pandas, NumPy, Scikit-learn, Matplotlib)
- Apache Spark
- Jupyter Notebooks
- Google Colabs
- GIS software (QGIS, ArcGIS Pro)
- Cloud platforms (e.g., AWS, Google Cloud)
- Remote sensing tools (e.g., Google Earth Engine)



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Module title: Climate Modelling and data analysis

Course overview/Preamble

This course is designed to introduce climate modeling to computer science students that underpin atmospheric phenomena and weather patterns, including the comprehensive study of the climate system and climate modeling. Climate Modelling is a method to address climate (change) with respect to identifying mechanisms, feedback, past changes and future changes. It is an essential tool to gain insight into global, regional and local changes in climate and the associated processes and feedback. It is also important to make reliable scenarios of future climate that can be used in energy, agriculture, and water by integrating Information and Communication Technology (ICT) to inform policy and decision making.

Duration

One semester

Credits/Hours

To be determined by individual institutions

Pre-requisites

- Introduction to climate change science

Objectives

To equip students with knowledge and skills needed in predicting future climate scenarios in order to develop practical adaptation and mitigation strategies in energy, agriculture, water and mine sectors.

Learning out comes

At the end of the course, the student is able to:

- Understand the energy balance and cycles for carbon, nitrogen and water

- Discuss the use of climate models
- Classify types of models, spatial, temporal scale
- Practice the use of a model in simulations
- Discuss the techniques involved in downscaling
- Describe the use of models in quantifying processes, feedbacks and in making future scenarios
- Identify for what questions climate models are used
- Discuss the type of simulations to be carried out with a climate model
- Evaluate outcome of modeling assignment in light of quantifying processes and results
- Apply ICT in climate modeling and their application in extractive industries
- Understand how climate modeling and climate prediction ("projection") are carried out, what some of the scenarios for the future are and the key sources of uncertainty
- Evaluate outcome of modeling assignment in light of simulation type

Module outline/Topics

1. Introduction to climate change – A Review
2. Energy balance, Hydrological, Carbon cycles, Nitrogen cycle
3. Paleo-climatological lines of evidence
4. Fundamental Forces, Pressure Gradient Force, Centrifugal Force, Gravity Force, Coriolis Force
5. Introduction to climate models and modeling
 - Basics of models: Concept of Parameterizations, time-stepping and resolution
 - Framework and process of model simulations
 - Types of Models
 - Uncertainties and sensitivity e. Case Studies
6. Introduction to Climate processes
 - Basic understanding on Climate Sciences
 - Uncertainty
 - IPCC and working Group 1 projections: Global to Regional aspects
 - Case Studies – illustrations
7. Numerical Weather Prediction (NWP): Fundamental equations of fluid motion in rotating and non-rotating fluid in different coordinate system, Principle of Weather Forecasting, General Circulation of atmosphere and Ocean, Kinematics & Circulation of pressure field and its application
8. Downscaling: Statistical downscaling, dynamical downscaling, Climate modeling chain (Bias adjustment), Observational and climate model data
9. Developing climate scenarios for V&A Assessments, Emission scenarios
10. Modeling and climate data analysis for green agriculture, green mining, green energy, groundwater, etc.



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11. Users and application of observational and climate model data in agriculture, mine, energy, water resources (underground water), etc.
12. Tools for climate data (Panoply, Python, R/Rstudio, QGIS, etc.)
13. Renewable Energy Potential Around the world
14. Potential for using renewable resources
15. Low-Carbon Energy Technologies
16. Climate change mitigation and adaptation actions
 - Agriculture
 - Mining
 - Water resources (groundwater)
 - Renewable energy
17. Generating climate services using ICT
18. Application of climate models – Modeling land use change, Agriculture, Mining (Using GIS, remote sensing, AI, Machine learning)

Practical

1. Running the energy balance model (compile and run a simple climate model)
2. Statistical downscaling and bias correction using Machine learning, Artificial Intelligence, etc.
3. Climate data analysis (Trend analysis for point and spatial data) using python
4. Validating climate modeled data using observations
5. Extracting point data from GCMs or RCMs using R/RStudio & python
6. Application of modeling in agriculture, energy, water resources (groundwater), mining (winds, erosion, etc.) using machine learning, Artificial Intelligence, R/Rstudio, etc.
7. Conduct CMIP-like, Reanalysis, satellite products & CODEX-AFR-44 multi-model analyses to test a hypothesis (agriculture, energy, water resources (groundwater), mining)

Assessments

Continuous Assessment contributes 50% while the final Examination 50% of the overall course grade.



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Prescribed readings

- IPCC, 2014: Annex II: Glossary [Mach, K.J., S. Planton and C. von Stechow (eds.)]. In: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, pp. 117-130.
- Goosse H., Barriat P.Y., Lefebvre W., Loutre M.F. and Zunz V., Introduction to Climate Dynamics and Climate Modeling.
- James R.H. An Introduction to Dynamic Meteorology, International Geophysics Series
- Steven A. Ackerman and John A. Knox, Meteorology Understanding the Atmosphere
- John Urry (2011) Climate Change and Society. Wiley-Blackwell. Essex, UK. ISBN: 978-0-7456-5037-1
- Kendal McGuffie, Ann Henderson-Sellers (2014) The Climate Modelling Primer, 4th Edition. Wiley-Blackwell. Essex, UK. ISBN: 978-1-119-94337-2
- Aslani, A., Naaranoja, M., & Wong, K. F. V. (2013). Strategic analysis of diffusion of renewable energy in the Nordic countries. Renewable and sustainable energy reviews, 22, 497- 505.

Recommended readings

- Geoffrey K.V. Atmospheric and Oceanic Fluid Dynamics: Fundamentals and Large-scale Circulation.
- Jacobson M.Z. Fundamentals of Atmospheric Modeling.
- McGuffie K. (Henderson-Sellers A., A Climate Modelling Primer, John Wiley & Sons.
- Taylor F.W. Elementary Climate Physics.
- Washington W.M. and Parkinson C.L. Introduction to Three-dimensional Climate Modeling
- Charles Fletcher (2012) Climate Change. Wiley-Blackwell. Essex, UK.
- Fung C. Fai, Ana Lopez, Mark New (Editors) (2010) Modelling the Impact of Climate Change on Water Resources. Wiley-Blackwell. Essex, UK. ISBN: 978-1-4051-9671-0 ISBN: 978-0-470-74002-6
- James A. Coakley Jr., Ping Yang (2014) Atmospheric Radiation: A Primer with Illustrative Solutions. Wiley-Blackwell. Essex, UK. ISBN: 978-3-527-41137-5
- Mike Christie, Andrew Cliffe, Philip Dawid, Stephen S. Senn (Editors) (2011) Simplicity, Complexity and Modelling. Wiley-Blackwell. Essex, UK.
- Richard W. Battarbee, Heather A. Binney (Editors) (2008) Natural Climate Variability and Global Warming: A Holocene Perspective. Wiley-Blackwell. Essex, UK. ISBN: 978-1-4051-5905-0
- Sarah E. Metcalfe, David J. Nash (Editors) (2012) Quaternary Environmental Change in the Tropics. Wiley-Blackwell. Essex, UK. ISBN: 978-1-118-34325-8

Tools

- R Programming software/RStudio
- Python
- Panoply



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The following are institution dependent:

- Assessment
- Course Codes
- Credits

Rhodes University- South Africa:

- Masters programme by research
- PhD by research

University of Eswatini -Eswatini:

- Masters programme taught
- PhD by research

Namibia University of Science and Technology -Namibia:

- Masters programme taught and research
- PhD by research

National University of Science and Technology -Zimbabwe:

- Masters programme taught and research
- PhD by research

The Copperbelt University -Zambia:

- Masters programme taught and research
- PhD by research