COLUMBIA UNIVERSITY
School of Professional Studies

Master of Science in Sustainable Management

SUMA PS6132 Climate Risk & Scenario Analysis

3 credits
Elective

Instructors: Satyajit Bose sgb2@columbia.edu

Dong Guo guodong@columbia.edu

Office Hours: By Appointment via Zoom:
Response Policy: I usually respond within 24 hours to email inquiries.

Facilitator/Teaching Assistant:
Office Hours:
Response Policy:

Course Overview

The course provides an overview of the scenario analysis and climate risk modeling process for corporate issuers and government entities. There is a brief introduction to the climate models utilized by the IPCC, both global and regional. There is a description of the scenario generation and analysis process, with linkages to benchmark scenarios outlined by international bodies. This is followed by a review of the linkages between climate models and socio-economic variables in the form of integrated assessment models, Ricardian models and economic input-output analysis. There is one module on the information systems needed to ensure good adaptation and a review of best practices and guidelines for climate risk management strategies. Integrated examples of climate risk and opportunities for specific issuers are discussed in the last 2 classes. The problem sets and exercises are designed to provide practice in applying high-level guidelines and climate damage relationships to the strategies and operations of specific countries, industries and companies.

The course has the following related goals:

1. To provide students with an introduction to the quantitative analysis of climate-related damages, cost differentials across mitigation approaches and the relative risk reduction value of adaptation investments.
2. To equip students with econometrically-equipped and geospatially aware approaches to analyze and interpret climate-related scenario analysis and integrate this knowledge into strategic planning and risk mitigation for corporations and governments.
3. To prepare students to understand and apply proposed SEC guidelines for the identification and quantification of climate risks, fostering alignment with industry practices and anticipating policy responses.

Who should take this course?

Adapted from: **The Course Syllabus: A Learning-Centered Approach, 2nd Edition,** Judith Grunert O'Brien, Barbara J. Millis, Margaret W. Cohen. ISBN: 978-0-470-60549-3. Available as an E-Book from Wiley at:
https://www.wiley.com/en-us/The+Course+Syllabus%3A+A+Learning+Centered+Approach%2C+2nd+Edition-p-9780470605493

- Sustainability practitioners seeking to enhance their skills in scenario analysis and climate risk assessment to drive positive environmental and business outcomes.
- Business professionals aiming to gain insights into climate risk management strategy and integrate environmental considerations into their decision-making processes.
- Finance professionals interested in understanding the implications of climate change for investment strategies and financial planning.

Learning Objectives

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

L1 **Describe methods of estimating climate damages:** Outline the methodologies and frameworks used for estimating climate-related damages to businesses and economies, and their significance in risk assessment

L2 **Identify business risks and opportunities:** Learn how to systematically identify, quantify, and assess the specific risks and opportunities that climate change poses to different sectors and industries, incorporating these insights into corporate strategy

L3 **Integrate scenario analysis:** Practice the implementation of risk management scenarios aligned with international standards and adapted to local conditions, so as to render such scenarios relevant to both strategic and operational decision making

L4 **Apply regulatory guidelines:** Assess the implications of proposed regulatory guidelines for the identification and quantification of climate risks, review organizational practices aligned with these guidelines, and prepare for potentially broader policy responses and supply chain impacts

L5 **Quantify value of adaptation investments:** Develop the ability to quantitatively assess the value of investments in adaptation strategies or climate-related opportunities, considering their potential returns and contributions to resilience in the face of climate related impacts

Required Readings

1. Aerts, J. C. (2018). A Review of Cost Estimates for Flood Adaptation. *Water, 10*(11). Retrieved from https://doi.org/10.3390/w10111646

2. Auffhammer, M. (2018). Quantifying Economic Damages from Climate Change. *Journal of Economic Perspectives 32*(4). pp 33-52.

3. Burke, M, Hsiang, S. & E. Miguel (2015) Global non-linear effect of temperature on economic production. Nature 527 (235-250)

4. C.-Y. Lin, C.-P. T. (2017). Procedure for selecting GCM datasets for climate risk assessment. *TAO : Terrestrial, Atmospheric and Oceanic Sciences, 28*(1), 43-51. doi:10.3319/TAO.2016.06.14.01(CCA)

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https://www.wiley.com/en-us/The+Course+Syllabus%3A+A+Learning+Centered+Approach%2C+2nd+Edition-p-9780470605493

5. David Bader, C. C. (2008). *Climate Models: An Assessment of Strengths and Limitations.* US Department of Energy Publications. Retrieved from https://digitalcommons.unl.edu/usdoepub/8

6. Dell, M., Jones, B.F. & Olken, B.A. (2014) What do we learn from the weather? The New Climate-Economy Literature. Journal of Economic Literature 52(3) 740-798.

7. ERAMS Clasic. (2021). *CLASIC Tool User Manual.* Retrieved from Community-enabled Lifecycle Analysis of Stormwater Infrastructure Costs (CLASIC): https://clasic.erams.com/static/er2_clasic/docs/CLASIC_UserGuide_case%20studies.pdf

8. Gillingham, K. & J.H. Stock (2018) The Cost of Reducing Greenhouse Gas Emissions. *Journal of Economic Perspectives* 32(4) 53-72.

9. Grippa, P., J. Schmittmann, and F. Suntheim. (2019). Climate Change and Financial Risk. *Finance & Development* 56 (4): 26–29

10. HW Tenfie, F. S. (2022). Selection of Representative General Circulation Models for Climate Change Study Using Advanced Envelope-Based and Past Performance Approach on Transboundary River Basin, a Case of Upper Blue Nile Basin, Ethiopia. *Sustainability, 4*. Retrieved from https://doi.org/10.3390/su14042140

11. IPCC. (2014). *Climate Change 2014: Impacts,Adaptation, and Vulnerability.* Cambridge: Cambridge University Press.

12. IPCC. (2021). *Climate Change 2021: The Physical Science Basis. Intergovernmental Panel on Climate Change.* Retrieved from https://www.ipcc.ch/report/ar6/wg1/downloads/report

13. J.P.Morgan. (2022, November). Climate scenarios: What they are, why they are important, and how they are applied to.

14. Khan, M. E., Mohaddes, K et al. (2021) Long-term macroeconomic effects of climate change: A cross-country analysis. *Energy Economics* 104 (105624)

15. Kamal Ahmed, D. A.-S. (2019). Selection of multi-model ensemble of general circulation models for the simulation of precipitation and maximum and minimum temperature based on spatial assessment metrics. *Hydrol. Earth Syst. Sci*, pp. 4803-4824. Retrieved from https://doi.org/10.5194/hess-23-4803-2019

16. Kompas, T., Pham, V.H. & T.N. Che (2018). The Effects of Climate Change on GDP by Country and the global economic gains by complying with the Paris climate accord. *Earth's Future*, 6, 1153–1173. https://doi.org/10.1029/2018EF000922

17. L Chee Wai, W. W. (2013). Crisis management: Western Digital's 46‐day recovery from the 2011 flood disaster in Thailand. *Strategy & Leadership, 41*(1), pp. 34-38. Retrieved from https://doi.org/10.1108/10878571311290061

18. McKinsey & Company. (2020, June 1). *Banking imperatives for managing climate risk*. Retrieved from Risk & Resilience:

https://www.mckinsey.com/capabilities/risk-and-resilience/our-insights/banking-imperatives-for-managing-climate-risk

19. MSCI. (2023). *Climate Action Indexes: Taking action for net-zero*.

20. T. Nakasu, M. Miyamoto, R. Bhula-or, T. Mokkhamakkul, S. Anantsuksomsri, Y. Amornkitvikai, S. Duangkaew, and T. Okazumi, "Finding the Devastating Economic Disaster's Root Causes of the 2011 Flood in Thailand: Why Did Supply Chains Make the Disaster Worse?," J. Disaster Res., Vol.15 No.5, pp. 556-570. https://doi.org/10.20965/jdr.2020.p0556

21. NGFS, N. f. (2020). *Guide to climate scenario analysis for central banks and supervisors.* https://www.ngfs.net/sites/default/files/medias/documents/ngfs_guide_scenario_analysis_final.pdf

22. Nguyen Thi Lan Huoung, Y. S. (2019). Economic impact of climate change on agriculture using Ricardian approach: A case of northwest Vietnam. *Journal of the Saudi Society of Agricultural Sciences, 18*(4), pp. 449-457. Retrieved from https://doi.org/10.1016/j.jssas.2018.02.006

23. Nordhaus, W. (2013). Integrated Economic and Climate Modeling. *Computable General Equilibrium Modeling*(ISSN 2211-6885), pp. 1069-1131. Retrieved from http://dx.doi.org/10.1016/B978-0-444-59568-3.00016-X

24. Nordhaus, W. D. (2017). Revisiting the social cost of carbon. *Earth, Atmospheric, and Planetary Sciences, 114*(7). Retrieved from https://doi.org/10.1073/pnas.1609244114

25. Nordhaus, W. D. (2020, February 3). *Scientific and Economic Background on DICE models*. Retrieved from DICE/RICE Models: https://williamnordhaus.com/dicerice-models

26. Raymond R. Tan, K. B. (2019). *Input-Output Models for Sustainable Industrial Systems: Implementation Using LINGO.* Retrieved from https://doi.org/10.1007/978-981-13-1873-3

27. TCFD. (2017). *Recommendations of the Task Force on Climate-related Financial Disclosures.* Retrieved from https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf

28. TCFD. (2017). *The Use of Scenario Analysis in Disclosure of Climate-Related Risks and Opportunities.* Retrieved from https://assets.bbhub.io/company/sites/60/2020/10/FINAL-TCFD-Technical-Supplement-062917.pdf

29. TNFD. (2023). *Getting started with adoption of the TNFD recommendations.* tnfd.global.

30. Tol, R.S.J. (2018). The Economic Impacts of Climate Change. *Review of Environmental Economics and Policy 12*(1), 4-25. https://doi.org/10.1093/reep/rex027

31. UNEP Finance Initiative. (2018). *Navigating a new Climate.* UNEP FI.

32. Yi Yang, W. W. (2017). USEEIO: A new and transparent United States environmentally-extended input-output model. *Journal of Cleaner Production, 158*, pp. 308-318. Retrieved from https://doi.org/10.1016/j.jclepro.2017.04.150

33. Yi Yang, Y. P.-S. (2022, February 15). High-Resolution Environmentally Extended Input-Output Model to Assess the Greenhouse Gas Impact of Electronics in South Korea. Environ Sci Technol, 56(4), pp. 2107-2114. doi:10.1021/acs.est.1c05451

Assignments and Assessments

Your final course grade will be computed using a weighted index of numeric grades that combine performance under written assignments (discussion boards and weekly assignments), attendance and participation, the midterm exam, and the final term project. The weighted index will be scaled into a letter grade scale from F to A+ based on an expectation that a class representative of the population of Columbia masters students will receive a median grade of B+ or A-.

Specific rubrics for each assignment will be provided on the Canvas course site. General evaluation criteria is provided in each description.

Participation (Individual) - 10% of final grade

Regular participation in class discussions and project activities is required. Students are expected to have done the readings for each session prior to the lecture. We expect your contributions to enhance the quality of the class experience for yourself and others.

Participation includes the pre-reading required for the class and participation in the online discussion boards. Both written and oral participation is expected.

Problem Sets (Individual) - 15% of final grade

Completion of three weekly problem sets that include solving simple quantitative problems with climate damage functions, risk decision analysis and computation of optimal adaptation strategies.

Scenario Analysis Tools (Groups of 3-4 people) - 15% of final grade

Regional climate simulation exercise using DICE/EnROADS tool

A climate scenario analysis exercise utilizing an Excel-based simulation tool will form the basis for a group exercise to evaluate the impact of assumed decarbonization pathways on regional macro-econonomic variables such as economic growth, employment rates and temperature changes. Groups will be provided with a specific region and a benchmarked scenario to simulate, with an emphasis on described the assumed relationships which drive the results.

Green infrastructure adaptation investment assessment using CLASIC Tool

In this assignment, students are expected to conduct a financial analysis of the cost of undertaking green infrastructure adaptation in an urban area to minimize the impacts of excessive rainfall caused by climate change on the city's infrastructure and to articulate the financial benefits of the investment. Each group will receive a specific land use area whose geospatial characteristics can be analyzed in the open source online tool CLASIC. The tool,

combined with desk research for cost estimates, can be used to estimate the probability and economic damage from urban flooding estimates.

Midterm Exam (Individual) - 30% of final grade

At the end of week 9, students are given 48 hours to complete a written take-home midterm exam. This exam will require students to evaluate the potential climate damages and opportunities, using quantitative analysis, for one out of 2-3 given organizations. Students will conduct desk research on the nature of the business, connect strategy and operations with benchmark scenarios and identify material climate risks and opportunities. Students will utilize climate damage relationships covered in the class readings to articulate a strategy for quantitatively assessing identified risks for the chosen organization. The report must include how strategy and operations are likely to be affected and how management may identify synergistic business opportunities. The analysis must include estimated impacts to revenues, operating income, asset and liability values. Students will be required to submit a Word document and supporting spreadsheets with their response of approximately 2,000 words, excluding references.

Final Term Project (Groups of 2-3 people) - 30% of final grade

The final project will require students to work in teams to prepare either a draft TCFD-style report with enhanced quantitative analysis for a corporate issuer, or a climate risks & opportunities strategy report for a government agency. Deliverables will consist of presentation recording, slide deck, Excel analysis and written report. Students will select the issuer or government entity. The written report is expected to be a draft climate risk report section suitable for publication under the proposed SEC climate disclosure guidelines.

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Grading

The final grade will be calculated as described below:

FINAL GRADING SCALE

Grade	Percentage
A+	98–100 %
A	93–97.9 %
A-	90–92.9 %
B+	87–89.9 %
B	83–86.9 %
B-	80–82.9 %
C+	77–79.9 %
C	73–76.9 %
C-	70–72.9 %
D	60–69.9 %
F	59.9% and below

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Assignment/Assessment	% Weight	Individual or Group/Team Grade
Class participation	10%	Individual
Problem sets	15%	Individual
Group climate tool-based exercises (simulation and adaptation)	15%	Group
Midterm: climate risk & opportunity report	30%	Individual
Final project:	30%	Group

Course Schedule/Course Calendar

SPS holds each member of its community responsible for understanding and abiding by the SPS Academic Integrity and Community Standards posted at http://sps.columbia.edu/student-life-and-alumni-relations/academic-integrity-and-community-standards . You are required to read these standards within the first few days of class. Ignorance of the School's policy concerning academic dishonesty shall not be a defense in any disciplinary proceedings.

Accessibility Columbia is committed to providing equal access to qualified students with documented disabilities. A student's disability status and reasonable accommodations are individually determined based upon disability documentation and related information gathered through the intake process. For more information regarding this service, please visit the University's Health Services website: http://health.columbia.edu/services/ods/support

Module/Week & Topic with specific dates	Topic Covered	Readings	Activities/Assignments for this module
Module 1 **Introduction**	● Understanding climate change and its impact on businesses. ● Importance of climate risk and scenario analysis ● SEC Climate risk disclosure	● (IPCC, 2021) (pp. 18-24) (6 pages) ● (TCFD, 2017) (pp. 1-30) (30 pages) ● (Tol, 2018) (21 pages)	Introduction to Student Backgrounds
Module 2 **Climate Modeling -I**	● Brief introduction to Global Climate Models (GCMs) ● Interannual Variation & Climate Variability ● Impact on supply chains with examples	● (IPCC, 2021) (pp. 6-17) (11 pages) ● (David Bader, 2008), Chapter 2. (18 pages) ● (C.-Y. Lin, 2017) (12 pages). ● Astrum. "What El Nino Will do to Earth in 2022." YouTube Video (15 minutes)	
Module 3 **Climate Modeling -II**	● Regional Climate Models, Downscaling, Meso-scale, synaptic scale	● (HW Tenfie, 2022) (18 pages) ● (Kamal Ahmed, 2019) (21 pages)	Problem Set
Module 4 **Scenario Analysis- I**	● Input variables, relationships, estimated uncertainty, output variables	● (J.P.Morgan, 2022) (8 pages) ● (TCFD, 2017) (pp. 12-28) (16 pages)	Problem Set

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Module 5 **Scenario Analysis - II**	• Benchmark scenarios: UNFCCC (RCP and SSP), IEA, NGFS	• (IPCC, 2021) (pp. 29-39) (10 pages) • (NGFS, 2020) (pp. 9-34) (25 pages)	Problem Set
Module 6 **Integrated Assessment Models- I**	• Introduction to IAMs • Different models used for scenario analysis and their pros/cons • Social cost of carbon	• (Raymond R. Tan, 2019) (pp. 1-28) (28 pages) • (Gillingham & Stock 2018) (20 pages) • (Khan, Mohaddes 2021) (13 pages)	
Module 7 **Integrated Assessment Models- II**	• Details on EnRoads Simulator and • Dynamic Integrated Climate-Economy (DICE) Model	• (Nordhaus W. D., Scientific and Economic Background on DICE models, 2020) • (Nordhaus W. , 2013) (11 pages). • (Nordhaus W. D., Revisiting the social cost of carbon, 2017) (pp. 1518-1523) (5 pages)	Simulation Exercise: Analyzing Climate-Econo my Interactions with the DICE Excel Model
Module 8 **Ricardian Models of Climate Impact**	• Panel-based econometric methods • Impact of weather realizations over time in a given geography • Linkages and extrapolation to impacts on economic growth	• Auffhammer (2018) (21 pages) • (Dell, Jones & Olken 2014) (58 pages) • (Burke, Hsiang & Miguel 2015) (16 pages) • (Nguyen Thi Lan Huoung, 2019) (9 pages).	
	Spring Break		
Module 9 **Sectoral Models of Climate Impact- I**	• Input Output Model Fundamentals for sustainable industrial system • Case studies • Matrix Algebra and Environmentally extended IOMs	• (Raymond R. Tan, 2019) (14 pages) • (Yi Yang, 2017) (10 pages)	Midterm
Module 10 **Sectoral Models of Climate Impact- II**	• Application of IOM models to assess GHG impact in Industries for different sectors	• (Yi Yang Y. P.-S., 2022) (7 pages) • (Kompas, Pham & Che 2018) (21 pages)	

Module 11 **Information and Adaptation**	• Early warning signals interpretation from regional models • Financing the adaptation techniques • Possibility of Maladaptation	• (Aerts, 2018) (pp. 1-33) (33 pages) • (ERAMS Clasic, 2021)	Green infrastructure economic analysis exercise using CLASIC tool
Module 12 **Risk management strategies**	• TCFD/TNFD, targets, governance • Climate VAR • Example Metric: FRBNY Global Supply Chain Pressure Index	• (TCFD, 2017) (pp. 1-30) (30 pages) • (TNFD, 2023) (pp. 1-20) (20 pages) • (MSCI, 2023) (pp 1-8) (8 pages) • (McKinsey & Company, 2020) (pp. 1-10) • (Grippa et 2019) (3 pages)	
Module 13 **Vulnerability Identification**	• Climate Change vulnerability and its impact on global economy • Identification of vulnerability and factors affecting it • Case Study: Thailand Flooding 2011	• (L Chee Wai, 2013) (4 pages). • (Tadashi Nakasu, 2020) (20 pages)	Presentation recordings and slide deck
Module 14 **Opportunity Identification**	• Opportunity Identification Framework • Application for different sectors • Case study: Electric Utility, PG&E and Tuscan Electric Power	• (UNEP Finance Initiative, 2018) (pp 53-69) (16 pages) • (TCFD, 2017) (pp. 32-39) (7 pages)	Final report and accompanying spreadsheets

Course Policies

Participation and Attendance
I expect you to come to class on time and thoroughly prepared. I will keep track of attendance and look forward to an interesting, lively and confidential discussion. If you miss an experience in class, you miss an important learning moment and the class misses your contribution. More than one absence will affect your grade.

Late work
Work that is not submitted on the due date noted in the course syllabus without advance notice and permission from the instructor will be graded down 1/3 of a grade for every day it is late (e.g., from a B+ to a B).

Citation & Submission
All written assignments must use standard citation format (e.g., MLA, APA, Chicago), cite sources, and be submitted to the course website (not via email).

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https://www.wiley.com/en-us/The+Course+Syllabus%3A+A+Learning+Centered+Approach%2C+2nd+Edition-p-9780470605493

School and University Policies and Resources

Copyright Policy
Please note—Due to copyright restrictions, online access to this material is limited to instructors and students currently registered for this course. Please be advised that by clicking the link to the electronic materials in this course, you have read and accept the following:

> The copyright law of the United States (Title 17, United States Code) governs the making of photocopies or other reproductions of copyrighted materials. Under certain conditions specified in the law, libraries and archives are authorized to furnish a photocopy or other reproduction. One of these specified conditions is that the photocopy or reproduction is not to be "used for any purpose other than private study, scholarship, or research." If a user makes a request for, or later uses, a photocopy or reproduction for purposes in excess of "fair use," that user may be liable for copyright infringement.

Academic Integrity
Columbia University expects its students to act with honesty and propriety at all times and to respect the rights of others. It is fundamental University policy that academic dishonesty in any guise or personal conduct of any sort that disrupts the life of the University or denigrates or endangers members of the University community is unacceptable and will be dealt with severely. It is essential to the academic integrity and vitality of this community that individuals do their own work and properly acknowledge the circumstances, ideas, sources, and assistance upon which that work is based. Academic honesty in class assignments and exams is expected of all students at all times.

SPS holds each member of its community responsible for understanding and abiding by the SPS Academic Integrity and Community Standards posted at https://sps.columbia.edu/students/student-support/academic-integrity-community-standards. You are required to read these standards within the first few days of class. Ignorance of the School's policy concerning academic dishonesty shall not be a defense in any disciplinary proceedings.

Diversity Statement
It is our intent that students from all diverse backgrounds and perspectives be well-served by this course, that students' learning needs be addressed both in and out of class, and that the diversity that the students bring to this class be viewed as a resource, strength and benefit. It is our intent to present materials and activities that are respectful of diversity: gender identity, sexuality, disability, age, socioeconomic status, ethnicity, race, nationality, religion, and culture.

Accessibility
Columbia is committed to providing equal access to qualified students with documented disabilities. A student's disability status and reasonable accommodations are individually determined based upon disability documentation and related information gathered through the intake process. For more information regarding this service, please visit the University's Health Services website: https://health.columbia.edu/content/disability-services.

Class Recordings
All or portions of the class may be recorded at the discretion of the Instructor to support your learning. At any point, the Instructor has the right to discontinue the recording if it is deemed to be obstructive to the learning process.

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https://www.wiley.com/en-us/The+Course+Syllabus%3A+A+Learning+Centered+Approach%2C+2nd+Edition-p-9780470605493

If the recording is posted, it is confidential and it is prohibited to share the recording outside of the class.

SPS Academic Resources
The Division of Student Affairs provides students with academic counseling and support services such as online tutoring and career coaching: https://sps.columbia.edu/students/student-support/student-support-resources.

Columbia University Information Technology
Columbia University Information Technology (CUIT) provides Columbia University students, faculty and staff with central computing and communications services. Students, faculty and staff may access University-provided and discounted software downloads.

Columbia University Library
Columbia's extensive library system ranks in the top five academic libraries in the nation, with many of its services and resources available online.

The Writing Center
The Writing Center provides writing support to undergraduate and graduate students through one-on-one consultations and workshops. They provide support at every stage of your writing, from brainstorming to final drafts. If you would like writing support, please visit the following site to learn about services offered and steps for scheduling an appointment. This resource is open to Columbia graduate students at no additional charge. Visit http://www.college.columbia.edu/core/uwp/writing-center.

Career Design Lab
The Career Design Lab supports current students and alumni with individualized career coaching including career assessment, resume & cover letter writing, agile internship job search strategy, personal branding, interview skills, career transitions, salary negotiations, and much more. Wherever you are in your career journey, the Career Design Lab team is here to support you. Link to https://careerdesignlab.sps.columbia.edu/

Netiquette

Online sessions in this course will be offered through Zoom, accessible through Canvas. A reliable Internet connection and functioning webcam and microphone are required. It is your responsibility to resolve any known technical issues prior to class. Your webcam should remain turned on for the duration of each class, and you should expect to be present the entire time. Avoid distractions and maintain professional etiquette.

Please note: Instructors may use Canvas or Zoom analytics in evaluating your online participation.

More guidance can be found at: https://jolt.merlot.org/vol6no1/mintu-wimsatt_0310.htm

Netiquette is a way of defining professionalism for collaborations and communication that take place in online environments. Here are some Student Guidelines for this class:

- Avoid using offensive language or language that is not appropriate for a professional setting.

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- Do not criticize or mock someone's abilities or skills.
- Communicate in a way that is clear, accurate and easy for others to understand.
- Balance collegiality with academic honesty.
- Keep an open-mind and be willing to express your opinion.
- Reflect on your statements and how they might impact others.
- Do not hesitate to ask for feedback.
- When in doubt, always check with your instructor for clarification

*************JUST FOR INTERNAL EASE*************

Module 1: Introduction

IPCC. (2021). *Climate Change 2021: The Physical Science Basis. Intergovernmental Panel on Climate Change.* (pp. 18-24) (6 pages)

TCFD. (2017). *The Use of Scenario Analysis in Disclosure of Climate-Related Risks and Opportunities*. (pp. 1-30) (30 pages)

Tol, R.S.J. (2018). The Economic Impacts of Climate Change. *Review of Environmental Economics and Policy 12*(1), 4-25. (21 pages)

Module 2: Climate Modelling I

IPCC. (2021). *Climate Change 2021: The Physical Science Basis. Intergovernmental Panel on Climate Change.* (pp. 6-17) (11 pages)
David Bader, C. C. (2008). *Climate Models: An Assessment of Strengths and Limitations.* US Department of Energy Publications. Chapter 2. (18 pages)
C.-Y. Lin, C.-P. T. (2017). Procedure for selecting GCM datasets for climate risk assessment. *TAO : Terrestrial, Atmospheric and Oceanic Sciences, 28*(1), 43-51. doi:10.3319/TAO.2016.06.14.01(CCA) (12 pages)
Khan, M. E., Mohaddes, K et al. (2021) Long-term macroeconomic effects of climate change: A cross-country analysis. *Energy Economics* 104 (105624)

https://www.youtube.com/watch?v=mggRl80WzbE (15 mins video)

Module 3: Climate Modelling II

W Tenfie, F. S. (2022). Selection of Representative General Circulation Models for Climate Change Study Using Advanced Envelope-Based and Past Performance Approach on Transboundary River Basin, a Case of Upper Blue Nile Basin, Ethiopia. *Sustainability,*(18 pages)

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Kamal Ahmed, D. A.-S. (2019). Selection of multi-model ensemble of general circulation models for the simulation of precipitation and maximum and minimum temperature based on spatial assessment metrics. *Hydrol. Earth Syst. Sci*, pp. 4803-4824. (21 pages)

Module 4:

J.P.Morgan. (2022, November). Climate scenarios: What they are, why they are important, and how they are applied to. (8 pages)
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Adapted from: **The Course Syllabus: A Learning-Centered Approach, 2nd Edition,** Judith Grunert O'Brien, Barbara J. Millis, Margaret W. Cohen. ISBN: 978-0-470-60549-3. Available as an E-Book from Wiley at:
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