Syllabus of Record

Program: CET Taiwan
Course Code / Title: (TP/ENVR 250) Climate Data and Climate Change Science in East Asia
Contact Hours: 45
Recommended Credits: 3
Primary Discipline / Suggested Cross Listings: Environmental Studies / Data Science, Public Policy, Asian Studies
Language of Instruction: English
Prerequisites: Previous Environmental Science coursework recommended but not required.

Description:
This course offers a thorough introduction to the fundamental physical processes underlying climate change, with a particular focus on global mechanisms and their regional implications for Taiwan. It will first introduce the basic knowledge/skill of climate science and then lead students to practice data visualization, understand climate narratives, and analyze climate service. The course examines the physical science behind Taiwan's past, present, and future climate change, comparing it with global trends. Topics include observational evidence, climate system components, the physical principles governing climate variability, and the role of anthropogenic factors. Special attention is given to climate extremes such as heatwaves, extreme rainfall, and drought.

Students engage with knowledge of climate change, climate variability, and extreme events relevant to Taiwan. The course also provides a comprehensive introduction to common methods used in processing climate and weather data, specifically through Python for beginners. In addition to data processing methods, the course provides an overview of basic concepts in atmospheric science, helping students gain a comprehensive understanding of the origin and nature of the datasets. Students are not required to have prior knowledge of the programming language Python, but they should be open to working with code.

Objectives:
The course has two primary objectives. Firstly, it aims to guide students in extracting information from climate and weather datasets using data visualization techniques. Secondly, it is designed to help students develop their own narratives based on this extracted information.

By the end of the course, students:

- Know fundamental physical processes underlying climate change and specialties of climate datasets.
- Are equipped with the necessary skills to process, analyze, and interpret climate datasets using Python.
- Understand how to get the information from climate/weather datasets by data visualization.
- Learn how to use this information to finalize their own narrative and try to address environmental issues.

Course requirements:
Students are expected to attend each class as outlined in the CET Attendance Policy. Active participation in the classroom is essential.

- **Class Participation:** Active participation is essential for success in this course.

Students must complete all assigned readings or viewings before each class session to fully engage in discussions. Reading assignments typically average 60 pages per class. In addition, students must come prepared to contribute thoughtfully during class, drawing on both the assigned materials and their own insights.

Class Participation Grading Rubric

	A – 90-100% Exemplary	**B – 80-89% Proficient**	**C – 70-79% Developing**	**D – 60-69% Unacceptable**	**F – 0-59% Missing**
Frequency of class participation	Actively contributes 2+ times per meeting	Actively contributes at least 1 time per meeting	Actively contributes at least half of the time during term	Actively contributes less than half of the time during term	Does not contribute
Quality of class participation *	Contribution is always thoughtful, accurate, and constructive, frequently interacting with peers	Contribution is mostly thoughtful, accurate, and constructive, usually interacting with peers	Contribution is somewhat thoughtful, accurate, and constructive, sometimes interacting with peers	Contribution is rarely thoughtful, accurate, and constructive, rarely interacting with peers	Does not contribute or interact with peers
Level of class preparation	Always fully prepared and on task	Mostly prepared and on task	Somewhat prepared and on task	Rarely prepared and on task	Consistently unprepared and not on task

- **Written Homework (HW) Assignments:**
  This course will have four assignments, which must be submitted by the specified deadlines. The assignments will involve climate data analysis and will utilize Python. Each assessment will include tasks such as reproducing assigned figures, writing figure descriptions, providing short comments on the reading material, and completing Python code.

  Each assignment will require the production of 3-5 figures. The figure captions should be 20-50 words, and the short comments should be 100-200 words. It will be graded based on the quality of the figures, the accuracy of the figures and their captions, and the quality of the short comments

- **Group Report**
  Students form small groups and pick a class-related climate issue topic for a 30-minute final presentation (25 mins presentation and 5 mins QA). Each group must also choose a climate service industry as their target audience, analyzing the specific climate information needs of that industry and generating relevant climate information accordingly. The location of the climate service is not restricted. The final report will consist of both written and oral components.

  Presentations are to include an introduction of the topic, a literature review, personal observations, critical analysis, and compare and contrast. Creativity in content and format is welcome.

  The written report must be at least 2,000 words in length to include what they presented in the oral presentation and should address the feedback they have received in the oral presentation. APA style.

Grading

The final grade is determined as follows:

Participation	20%
Written Homework Assignments (4 at 10%)	40%
Group Report	40%

- Presentation: 20%
- Written report: 20%

Readings

2022 Adaptation Communication, The Government of Republic of China (Taiwan), https://www.cca.gov.tw/en/information-service/publications/adaptation-communication/11793.html

AR6 Synthesis Report: Climate Change 2023 The IPCC finalized the Synthesis Report for the Sixth Assessment Report

Barriopedro, D., García-Herrera, R., Ordóñez, C., Miralles, D. G., & Salcedo-Sanz, S. (2023). Heat waves: Physical understanding and scientific challenges. Reviews of Geophysics, 61(2), e2022RG000780.

Bucchi, M. (2008). Of deficits, deviations and dialogues: Theories of public communication of science. In M. Bucchi & B. Trench (Eds.), Handbook of public communication of science and technology (pp. 57–76). New York: Routledge.

Cassou, C., Kushnir, Y., Hawkins, E., Pirani, A., Kucharski, F., Kang, I. S., & Caltabiano, N. (2018). Decadal climate variability and predictability: Challenges and opportunities. Bulletin of the American Meteorological Society, 99(3), 479-490.

Chand, S. S., Walsh, K. J., Camargo, S. J., Kossin, J. P., Tory, K. J., Wehner, M. F., ... & Murakami, H. (2022). Declining tropical cyclone frequency under global warming. Nature Climate Change, 12(7), 655-661.

Chia Chou, and Coauthors, 2018: Climate Change in Taiwan: Scientific Report 2017. National Science Council, Executive Yuan: Taipei, Taiwan.

Climate Change Adaptation Plan, The District Department of Transportation, District of Columbia.

Climate Change Adaption Plan (2020), The Royal Melbourne Institute of Technology.

Climate Services for Supporting Climate Change Adaptation

Chou, C., Huang, L. F., Tseng, L., Tu, J. Y., & Tan, P. H. (2009). Annual cycle of rainfall in the western North Pacific and East Asian sector. Journal of Climate, 22(8), 2073-2094.

David I. Armstrong McKay et al. (2022). Exceeding 1.5°C global warming could trigger multiple climate tipping points. Science 377, eabn7950. DOI:10.1126/science.abn7950

Dunstone, N., Lockwood, J., Solaraju-Murali, B., Reinhardt, K., Tsartsali, E. E., Athanasiadis, P. J., ... & Thornton, H. E. (2022). Towards useful decadal climate services. Bulletin of the American Meteorological Society, 103(7), E1705-E1719.

Eyring, V., Bony, S., Meehl, G. A., Senior, C. A., Stevens, B., Stouffer, R. J., & Taylor, K. E. (2016). Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization. Geoscientific Model Development, 9(5), 1937-1958.

Gettelman, Andrew et al. (2022). The future of Earth system prediction: Advances in model-data fusion. Sci. Adv. 8, eabn3488. DOI:10.1126/sciadv.abn3488

He, C., Kim, H., Hashizume, M. et al. (2024). The overlooked health impacts of extreme rainfall exposure in 30 East Asian cities. Nat Sustain 7, 423–431. https://doi.org/10.1038/s41893-024-01294-x

Henny, L., C. D. Thorncroft, H.-H. Hsu, and L. F. Bosart (2021). Extreme rainfall in Taiwan: Seasonal statistics and trends. Journal of Climate, 34, 4711-4731.

Henny, L., C. D. Thorncroft, H. H. Hsu, and L. F. Bosart (2023). Changes in extreme precipitation in Taiwan's Mei-yu season. Quarterly Journal of the Royal Meteorological Society, 149, 1810-1832.

Hewitt, C., Mason, S. & Walland, D. (2012). The Global Framework for Climate Services. Nature Clim Change 2, 831–832. https://doi.org/10.1038/nclimate1745

Hong, C. C., Hsu, H. H., Chia, H. H., & Wu, C. Y. (2008). Decadal relationship between the North Atlantic Oscillation and cold surge frequency in Taiwan. Geophysical Research Letters, 35(24).

Hsu, H. H., & Chen, Y. L. (2011). Decadal to bi-decadal rainfall variation in the western Pacific: A footprint of South Pacific decadal variability?. Geophysical research letters, 38(3).

Huang WanRu, H. W., Wang, S. Y. S., & Guan, B. T. (2018). Decadal fluctuations in the

western Pacific recorded by long precipitation records in Taiwan.

Hung, C.-w., and M.-F. Shih (2019). Analysis of severe droughts in taiwan and its related atmospheric and oceanic environments. Atmosphere, 10, 159.

International Organization for Standardization. (2020). Adaptation to climate change — Requirements and guidance on adaptation planning for local governments and communities (ISO Standard No. 14092:2020).

IPCC AR6 Climate Change 2021: The Physical Science Basis, https://www.ipcc.ch/report/ar6/wg1/

Jensen EA and Gerber A (2020) Evidence-Based Science Communication. Front. Commun. 4:78. doi: 10.3389/fcomm.2019.00078

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Liu, J.CE., Zhao, B. (2017). Who speaks for climate change in China? Evidence from Weibo. Climatic Change 140, 413–422. https://doi.org/10.1007/s10584-016-1883-y

Lo, T.-T., and H.-H. Hsu (2008). The early 1950s regime shift in temperature in Taiwan and East Asia. Climate dynamics, 31, 449-461.

Mardani, M., Brenowitz, N., Cohen, Y., Pathak, J., Chen, C. Y., Liu, C. C., ... & Pritchard, M. (2024). Residual Diffusion Modeling for Km-scale Atmospheric Downscaling.

Meehl, G. A., Richter, J. H., Teng, H., Capotondi, A., Cobb, K., Doblas-Reyes, F., ... & Xie, S. P. (2021). Initialized Earth System prediction from subseasonal to decadal timescales. Nature Reviews Earth & Environment, 2(5), 340-357.

Mora, C., Dousset, B., Caldwell, I. R., Powell, F. E., Geronimo, R. C., Bielecki, C. R., ... & Trauernicht, C. (2017). Global risk of deadly heat. Nature climate change, 7(7), 501-506.

Moser, Susanne. (2010). Communicating climate change: History, challenges, process and future directions. Wiley Interdisciplinary Reviews: Climate Change. 1. 31-53. 10.1002/wcc.11.

Murray, D., Hoell, A., Hoerling, M., Perlwitz, J., Quan, X. W., Allured, D., ... & Webb, R. S. (2020). Facility for weather and climate assessments (FACTS): a community resource for assessing weather and climate variability. Bulletin of the American Meteorological Society, 101(7), E1214-E1224.

Owen, R., Fisher, E. and McKenzie, K. (2013). Beyond reduction: climate change adaptation planning for universities and colleges, International Journal of Sustainability in Higher Education, Vol. 14 No. 2, pp. 146-159. https://doi.org/10.1108/14676371311312860

Peduzzi, P., Chatenoux, B., Dao, H., De Bono, A., Herold, C., Kossin, J., ... & Nordbeck, O. (2012). Global trends in tropical cyclone risk. Nature climate change, 2(4), 289-294.

Priority Needs for the Operationalization of the Global Framework for Climate Services (2016–2018)

Principles for effective communication and public engagement on climate change, https://climateoutreach.org/reports/ipcc-communications-handbook/

Randy Olson. 2015. Houston, We Have a Narrative. University of Chicago Press, ISBN-10: 022627084X, ISBN-13: 978-0226270845, 256 pages.

Riahi, K., Van Vuuren, D. P., Kriegler, E., Edmonds, J., O'neill, B. C., Fujimori, S., ... & Tavoni, M. (2017). The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview. Global environmental change, 42, 153-168.

The concept of risk in the IPCC Sixth Assessment Report: a summary of cross Working Group discussions

The Nobel Prize in Physics 2021: For groundbreaking contributions to our understanding of complex physical systems

The Nobel Prize in Physics 2021: They found hidden patterns in the climate and in other complex phenomena

Tokarska, K. B., Stolpe, M. B., Sippel, S., Fischer, E. M., Smith, C. J., Lehner, F., & Knutti, R. (2020). Past warming trend constrains future warming in CMIP6 models. Science advances, 6(12), eaaz9549.

Tseng, W. L., Lin, S. Y., Wang, Y. C., Lo, S. H., Lo, M. H., Lee, S. Y., ... & Hsu, H. H. (2023). Impact of Pacific–Japan pattern on temperature and heatwave events in summer over Taiwan. International Journal of Climatology, 43(15), 7067-7081.

U.S. Environmental Protection Agency Climate Adaptation Action Plan (2021), U.S. Environmental Protection Agency.

Vu, H. T., Blomberg, M., Seo, H., Liu, Y., Shayesteh, F., & Do, H. V. (2021). Social Media and Environmental Activism: Framing Climate Change on Facebook by Global NGOs. Science Communication, 43(1), 91-115. https://doi.org/10.1177/1075547020971644

Wang, Y. C., Hsu, H. H., Chen, C. A., Tseng, W. L., Hsu, P. C., Lin, C. W., ... & Shiu, C. J. (2021). Performance of the Taiwan earth system model in simulating climate variability compared with observations and CMIP6 model simulations. Journal of Advances in Modeling Earth Systems, 13(7), e2020MS002353.

Zscheischler, J., Martius, O., Westra, S., Bevacqua, E., Raymond, C., Horton, R. M., ... & Vignotto, E. (2020). A typology of compound weather and climate events. Nature reviews earth & environment, 1(7), 333-347.

Zscheischler, J., Westra, S., Van Den Hurk, B. J., Seneviratne, S. I., Ward, P. J., Pitman, A., ... & Zhang, X. (2018). Future climate risk from compound events. Nature climate change,

8(6), 469-477.

Outline of Course Content

Topic 1 – Introduction to the Intergovernmental Panel on Climate Change (IPCC) Working Group I

- Understanding the fundamental question of climate from IPCC AR6
- Future global climate: scenario-based projections and near-term information

Topic 2 – Climate Change Report in Taiwan

- Taiwan Climate Change Projection and Information Platform, TCCIP
- Temperature, rainfall, and wind
- Extreme Events and Air Pollution

Topic 3 – How do we generate climate projections results?

- Introduction of Earth system models (ESM)
- Downscaling methods

Topic 4 – Climate Variability in East Asia

- Overview of major climate variability patterns in East Asia, including ENSO, PDO, and monsoon systems.
- Examination of the impacts of these climate variability patterns on East Asia.

Topic 5 – Climate Data Analysis

- Basic Syntax of Python
- Typical Data visualization methods in climate-related reports

Topic 6 – Climate change mitigation or adaptation?

Topic 7 – Climate Service

- Understand how climate information can be applied in methodologies and tools for adaptation to climate change

Topic 8 – Earth Science Communication

Topic 9 – Scale & Uncertainty