Indian Institute of Technology Kanpur
Kotak School of Sustainability

Proposal for a new course

Course Title: Modelling Extreme Weather Events using Statistical and AI Tools
Course No: KSS 6XX

About the course: The course will provide an overview of statistical methods for extreme event analysis which is essential for the hydrologic design of resilient infrastructure and early warning systems under climate change. The course will introduce the concept of reliability and serviceability of infrastructure, futuristic design values, frequency analysis and extreme value theory, uncertainty analysis, statistical tools and AI/ML applications for modelling hydroclimatic extremes. The course will focus on building theoretical understanding and emphasize on the application of concepts, with a significant weightage on application-oriented class project on applying statistical and Machine Learning (ML) tools for extreme event modelling.

Learning Outcomes: The course will train the students in different aspects of modelling extreme weather events under stationary and non-stationary climate. They will learn to work with in-situ observations, satellite datasets and simulations, will become proficient in programming as well as in applying statistical and ML tools appropriate for modelling different extreme events. Biweekly assignments and course project will help the students to apply the skills learned in the course on real-life problems.

Course Evaluation Components:
The course evaluation will be based on continuous assessment of students throughout the semester with the following weightage on different components.

- Course Project: 30%
- Mid/End Semester Exams: 30%
- Class Assignments: 25%
- Quizzes:10%
- Class Participation: 5%

Participating Departments for floating the course: KSS
Possible Proposers: Nanditha J. S. (KSS), Tushar Apurv (CE)
Faculty members interested in teaching: Nanditha J. S. (KSS)
Who can take the course: Ph. D, M. Tech., Final year B. Tech students. Particularly students in the departments of Kotak School of Sustainability, Civil Engineering, Earth Sciences will be interested in the course.
Units: 3-0-0-0-9 [9 credits]
Prerequisite: None

Course Contents and Lecture layout:
This course provides a comprehensive overview of state-of-the-art methodologies for modelling hydroclimatic extremes. It begins with fundamental concepts of hydrologic design, risk, and reliability, and proceeds to the statistical foundations of extreme event analysis. Students will gain advanced understanding of statistical methods such as extreme value theory, probability concepts, and approaches to modelling extremes under both stationary and changing climates. The course also introduces challenges associated with non-stationarity,

climate projections, and downscaling techniques. In addition, it covers uncertainty analysis, probabilistic forecasting systems, and recent advances in applying AI/ML techniques to extreme event modelling. A final project will allow students to explore a topic of their choice, cementing their conceptual understanding and enhancing both technical knowledge and critical analysis skills.

Sl. No.	Topic	Number of Lectures
1.	Introduction: Hydroclimatic extremes and hydrologic design concepts, hydrologic risk and reliability.	3
2.	*Modelling of extreme weather events under stationary climate:* Extreme precipitation, floods, droughts, heatwaves; extreme value theory, frequency analysis, POT and block maxima approaches, skewed probability distributions, Review of classical and advanced statistical models.	6
	Intensity-Duration-Frequency (IDF) curves for infrastructure design, statistical methods and ML tools.	5
	Compound extremes and joint probability distribution functions (PDFs), Copula approach for multivariate distributions.	4
3.	*Modelling of extreme weather events under climate change:* Concepts of non-stationarity, natural variability and climate change, climate projections	4
	Global Climate Models (GCMs), biases, bias correction and statistical downscaling approaches, challenges in using GCM projections for extreme event modelling, IDF curves under climate change.	6
4.	Uncertainty Analysis: uncertainty quantification and propagation.	3
5.	Forecast of extreme events: State-of -the-art probabilistic forecast systems, discussions and challenges of existing systems.	2
6.	Applications of AI/ML in extreme event modelling. Review of recent advances.	3
7.	Final project design and presentations	3

Textbooks and References

1. Risk and Reliability analysis – Vijay P. Singh, Sharad K. Jain, Aditya Tyagi, ASCE Press, 2007
2. An Introduction to Statistical Modeling of Extreme Values — Stuart Coles, Springer Series in Statistics, 2001
3. Statistical Modelling in Hydrology – Robin T. Clarke, Wiley & Sons, 1994
4. Serinaldi, F., & Kilsby, C. G. (2015). Stationarity is undead: Uncertainty dominates the distribution of extremes. *Advances in Water Resources*, *77*, 17-36.
5. Milly, P., Julio, B., Malin, F., Robert, M., Zbigniew, W., Dennis, P., & Ronald, J. (2007). Stationarity is dead. *Ground Water News & Views*, *4*(1), 6-8.
6. Daly, C., Gibson, W. P., Taylor, G. H., Doggett, M. K., & Smith, J. I. (2007). Observer bias in daily precipitation measurements at United States cooperative network stations. *Bulletin of the American Meteorological Society*, *88*(6), 899-912.
7. Naveau, P., Huser, R., Ribereau, P., & Hannart, A. (2016). Modeling jointly low, moderate, and heavy rainfall intensities without a threshold selection. *Water Resources Research*, *52*(4), 2753-2769.

Dated: 19th Jan 2026 Proposer: Nanditha J. S.

Dated: 19th Jan 2026 **DUGC/DPGC Convener**

The course is approved / not approved

Chairman, SUGC/SPGC

Dated: _____