NCSU Department of Civil, Construction and Environmental Engineering
CE 586: Engineering Hydrology – Fall 2024

Section 001 & 601:1:30-2:45 PM W, F; 2220 Engineering Building 3, Centennial Campus

Instructor : Dr. Sankar Arumugam (sankar_arumugam@ncsu.edu), 3321 Fitts-Woolard Hall (FWH); (919)515-7700; Dr. Jeongwoo Hwang (jhwang24@ncsu.edu); 3346 FWH

Office Hours (On-campus or zoom) : W,F: 10-11 AM or by appointment.
Office Hours (EOL – only Zoom) : Wednesdays: 3-5 PM or by appointment (by zoom)

Office Hours Zoom Link (for both the instructor and the TA):
https://ncsu.zoom.us/j/9895685820?pwd=MitsT1JSMmFDWXVjdm1yNzdpSjZTdz09

Teaching Assistant: Kichul Bae (kbae@ncsu.edu)

Syllabus :

Introduction – Hydrological Processes in space and time – Water balance and Hydrological Cycle – Continuity Equation – Global Climate System – El Nino – Precipitation and Atmospheric Water – Energy Balance – Evapotranspiration – Snow and Snowmelt –Runoff Generation and Stream Response - Frequency Analyses – Design Flood Estimation – Lumped and Distributed Watershed Models

Text : Physical Hydrology by Dingman, Third Edition, Waveland Press.

Course Purpose: CE 586 prepares you to develop engineering solutions to hydrological problems by emphasizing the inter-linkages of processes in hydrological cycle. More fundamentally, the course approaches hydrologic design from the perspective of space-time scales associated with different hydroclimatological processes. Modeling of these processes by considering both mass and energy balance provide basic framework for estimation of hydrological fluxes at the watershed scale. However, alternate methods including systems approach and statistical estimation techniques will be covered for estimation of fluxes for basins with minimal data.

Prerequisite: Students must read appendices (A, B, C and D) and it will not be covered separately in the class. However, enough material will be drawn from appendices for modeling the hydrological processes.

Course Objectives: By the end of the course, you should be able to:
(a) Explain the importance of hydrological processes and space-time scales associated with them
(b) Quantify them by expressing them using mass and energy balance as well as estimate them based on system approaches and statistical techniques
(c) Estimate the design parameters for the hydrological problems based on both constant risk and dynamic risk associated with changing climate conditions
(d) Identify the relevant processes for the given water management issues by choosing appropriate space-time scales to estimate them.

Instructions for On-campus Students: This course will be captured and distributed via the Internet and/or electronic media as part of the Engineering Online (EOL) program for the distance students. On-campus students can use this to access the lecture, but all are strongly attend the class during regular class sessions. These video recordings may contain an image of you entering the classroom, asking a question or being a part of the studio class. Please notify Dr. Linda Krute, Director of EOL, in writing

at ldkrute@ncsu.edu if you DO NOT want your image to be included in the lecture presentation. If we do not hear from you after the first week of the class, we will assume that you agree with this procedure.

Grading:

Homework	-	20%
Mini-Project	-	15%
Exam-I	-	20%
Exam-II	-	20%
Final Exam	-	25%

Homework: Homework will be assigned on Thursday and it will be due within two weeks. Solution to challenging problems in the homework will be discussed in the beginning of the class on the due date. No credit will be given for late submission. Students are strongly encouraged to discuss and work in groups, but assignments must be submitted individually. No group submission is allowed. Evaluated assignments will be returned after a week from the due date.

The course has a total of five assignments. Evaluation of the homework is not purely based on the correct answer, but 10% of the credit in the homework will be given for providing detailed discussion and interpretation of the results. So, treat each homework assignment as a mini-project and provide a clean written report. All EOL and on-campus students need to submit the assignment report in wolfware. Due date for the last assignment could fall in the dead week of the class.

Mini-Project: The project will be assigned in the middle of October. It will be on using SWAT model for calibration and validation over the Upper Cape Fear River basin. Students are allowed to form a group with each having not more than two students. Evaluation of the mini-project (10% of total grade) will be based on analyses and report.

Exams: All exams will be an open book exam. Students are encouraged to write important formulae and conversions in a letter size sheet so that they do not have to memorize them for the tests. However, it is up to the students to write whatever they wish in the help sheets. Students can use any material they wish for the take-home exam if they are assigned. Any excuse/absence for the exams should be informed to the instructor well in advance and medical certificate should be provided if the requested absence is due to medical reasons.

Moodle Course webpage: This course will use Wolfware for updating the material, syllabus and assignments related to the class. On-campus and EOL (Section 601): https://wolfware.ncsu.edu sections will be combined together and all the material will be posted under the 601 section. If a particular assignment specifically requests you to load your excel sheet in Moodle, make sure you submit the excel sheet. Otherwise, the assignment will not be graded. Instructions for submitting each assignment will be available in the course webpage as well as in the assigned homework sheet. You can always check announcements and due dates for the homework from the course webpage.

Discussion Forum in Moodle: The course will open a discussion forum which students can use to discuss assignments and class material with peers. Instructor will oversee the discussion and post reply if relevant. All questions related to the assignment and class material need to be discussed through office hours or through mail. Students cannot expect the instructor/TA to answer questions through the discussion forum, which is primarily to discuss with other students in the class.

Additional Instructions due to COVID: Instructor will teach through online during regular class time and will also keep regular office hours both in-person and by zoom for EOL students. Class lectures and notes (as a pdf) will be posted in the EOL website. Students having any issues in accessing the

lectures/notes should inform the faculty immediately. TA will also keep regular office hours through zoom. Discussion forum will also provide additional opportunity beyond in-class discussion.

Academic Integrity: Students should refer to the University policy on academic integrity found in the Code of Student Conduct. The policy can also be obtained at:
http://www.ncsu.edu/policies/student_services/student_discipline/POL11.35.1.php
Policies and procedures detailed in the above website will be strictly enforced in the class. It is the responsibility of the students to read it and follow those procedures in the class.

Office of Disability Services: This class will enforce all the guidelines related to services for students with disabilities. More information can be found at http://www.ncsu.edu/dss/. Students in need of service are requested to get permission from the Office of Disability Services located at 1900 Student Health Center, (919) 515-7653.

Instructor Evaluation: Online class evaluations will be available for students to complete during the last two weeks of class. Students will receive an email message directing them to a website where they can login using their Unity ID and complete evaluations. All evaluations are confidential; instructors will never know how any one student responded to any question, and students will never know the ratings for any particular instructor.
Evaluation website: https://classeval.ncsu.edu

Tentative Schedule

Dates	Topic	Chapters
08/21	**Introduction (1 Class)** • Space-Time scales in hydrology and their linkage to water management • Challenges in hydrological fluxes estimation	1-1.2, 1.9
08/23-08/30	**Water Balance and Hydrological Cycle (3 classes)** • Continuity Equation (Mass), Regional Water Balance • Application to Reservoir Mass Balance • Role of Storage, Residence Time	1.6-1.8, 1.10
09/04-09/06	**Water Balance Models – Calibration and Validation (2 classes)** • Water balance models – 'abcd' model formulation • Calibration and validation • Equifinality in watershed model calibration	Appendix F
09/11-09/18	**Statistics – Review (3 classes)** • Random variables, Probability distributions – pdf, cdf, moments • Exceedence Probability and Return period events, correlation, lag-one correlation **Space-Time Variability of Hydrological Fluxes** • Time variability – Flow Duration Curves • Spatial variability – Point and Spatial Estimates	Appendix C, 1.9 and 1.11
09/20-10/02	**Global Climate System and Hydrological Cycle (4 classes)** • Energy budget of the earth – Role of co_2 and climate change • Moisture and energy balance integration – global and local scale • Climate variability – ENSO dynamics and teleconnection • Probabilistic Streamflow Forecasting –Regression and Resampling techniques	2.0-2.1, Handouts
10/02 **10/04**	**Exam-I Review** **Exam-I (Space-time aspects, Water and Energy Balance, Statistics)**	
10/09-10/16	**Precipitation and its Estimation (3 classes)** • Water Vapor Measurement – Vapor pressure, Abs. and Rel. Humidity, Dew point • Formation – Cooling, Condensation, Droplets, Importation, Adiabatic lapse rate • Mechanisms – Uplift due to Convergence, Orography Convection • Seasonality in Precipitation – Issues and Quantification • IDF curves, center-weighted storm and NRCS type-II distribution	3.0-3.2, 3.4 4.1, 4.4
10/18-10/25	**Snow and Snowmelt, Estimation (3 classes)** • Role of snow storage, Properties – Density, Snow Water equivalent • Energy Balance Method for Snow Melt Estimation, Temperature Index method • Field visit – Lake Wheeler ECONET site **(1 class) – Date TBD**	5.0-5.7
10/30-11/08	**Evapotranspiration Physics and Estimation (4 classes)** • Physics of Evaporation – Latent Heat Transfer, Mass Transfer • Estimation– Mass Transfer, Energy Balance and Combination method • Pan Evaporation, Potential Evaporation • Penman-Monteith method	3.5, 6.1-6.8
11/08 **11/13**	**Exam-II review** **Exam-II (Climate, Precipitation, Snowmelt) – Review on 11/18 – Take Home**	
11/15-11/22	**Watershed Modeling (3 classes)** • Lumped, semi-distributed and distributed models – Overview paper • HEC models • AI-based water balance models	Handouts and examples
12/06	**Final Exam (Comprehensive): 12-2:30 PM**	-