GGS354: Data Analysis and Global Change Detection Techniques

Instructor: Ruixin Yang
Exploratory Hall 2409**, Tel: 703-993-3615, E-mail:** ryang@gmu.edu

Time & Place: Thursdays, 4:30 pm-7:10 pm, Exploratory Hall 2310
Office Hours: Thursdays, 2:30 pm-4:00 pm and/or by appointment

Text Books:

- **Text 1 (recommended)**: IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp. (***Available in electronic form for free***)
  Updated info: IPCC released updated AR6 Climate Change 2021 recently. For accessing the report, one may visit: https://www.ipcc.ch/report/ar6/wg1/

- **Text 2 (recommended)**: Kendall, Maurice G., 1989, "Time Series," Oxford University Press, 3rd edition, December 1989. (ISBN-10: 0195207068; ISBN-13: 978019520706).

GMU Catalog Entry:

GGS 354 - Data Analysis and Global Change Detection Techniques (Credits: 3)

Introduces basic time series methods, especially those used in detecting trends and randomness in time series data. Various data related to global changes on different temporal and spatial scales will be identified, and the relevant analysis methods will be used to those data so that students can detect or confirm changing trends or lack of them in data. Other topics such as data formats, data visualization, and data mining may also be included based on the background of the student body.

Prerequisites

IT 104, STAT 250 or permission of instructor (*Competency in basic programming or tools used in data analysis*).

Goals and Objectives:

To introduce basic time series methods, especially those used in detecting trends and randomness in time series data. To present various data related to global changes on different temporal and spatial scales and data quality issues. To combine the relevant analysis methods with climate data so that students can detect or confirm changing trends or lack of them in data.

Learning Outcomes:

After successful completion of this course,

1. Students will understand basic time series analysis methods.
2. Students will become familiar with climate data.
3. Students will be able to analyze climate data sets and to make conclusions based on the analysis results.

4. Students will be able to apply the time series analysis methods and implementation skills to other data in real world situations.

Course Web Site: Blackboard Learn (gmu.edu). You must be familiar with the system for accessing course materials/assignments and for the final exam/project submissions.

Computing Requirements: No specific statistical package/tool will be required for assignments in this course. However, either Microsoft Excel (and the Excel Analysis ToolPak) or Matlab programming are recommended for assignments, tests, and/or projects. However, it is open for you to choose other statistical tools or programming environments such as Python.

Prerequisite Skills: A good comprehension of algebra and basic trigonometry and familiar with Microsoft Excel and/or a programming language. Basic calculus is helpful but not required.

Grading Policy:

Homework Assignments:	45% (50% for Fall 2020)
Attendances:	5% (0% for Fall 2020)
Mid-term Exam (take-home)	20%
Final Exam (take-home) or Project (?)	30%
Total	100% **(Letter grades based on absolute/relative numbers)**

General Course Policies

- Attendance will be considered in the final grade.
- See the general rubrics.
- No make-up exams and no incompletes grade.

Other references (This partial list is for information only. Not all the references will be used for the course in a particular semester):

Mann, M. E. (2004), On smoothing potentially nonstationary climate time series, Geophys. Res. Lett., 31, L07214, doi:10.1029/2004GL019569.

Mann, M. E. (2008), Smoothing of climate time series revisited, Geophys. Res. Lett., 35, L16708, doi:10.1029/2008GL034716.

Wilks, Daniel S., 2005: "*Statistical Methods in the Atmospheric Sciences: An Introduction*," Academic Press, December 2005 (0127519661)

McGrew, J. Chapman, Jr. and Charles B. Monroe, 2000, "An Introduction to Statistical Problem Solving in Geography," (2nd edition), McGraw Hill, Boston. (ISBN-10: 157766633X; ISBN-13: 9781577666332)

- **Data Links**

The followings are university wide required information from Office of the Provost:

UNIVERSITY POLICIES

- **University Catalog:** The University Catalog, http://catalog.gmu.edu, is the central resource for university policies affecting student, faculty, and staff conduct in university academic affairs. Other

policies are available at http://universitypolicy.gmu.edu/. All members of the university community are responsible for knowing and following established policies.

- **Sexual Harassment*:*** As a faculty member and designated "Responsible Employee," I am required to report all disclosures of sexual assault, interpersonal violence, and stalking to Mason's *Title IX Coordinator* per *university policy 1412*. If you wish to speak with someone confidentially, please contact the *Student Support and Advocacy Center* (703-380-1434) or *Counseling and Psychological Services* (703-993-2380). You may also seek assistance from *Mason's Title IX Coordinator* (703-993-8730; *titleix@gmu.edu*).
- **Academic Integrity** (from Mason Stearns Center for Teaching and Learning): Mason is an Honor Code university; please see the Office for Academic Integrity for a full description of the code and the honor committee process. Three fundamental principles to follow at all times are that: (1) all work submitted be your own, as defined by the assignment; (2) when you use the work, the words, or the ideas of others, including fellow students or online sites, you give full credit through accurate citations; and (3) if you are uncertain about the ground rules on a particular assignment or exam, ask for clarification. No grade is important enough to justify academic misconduct.
- **Generative-AI (GenAI) Tools:** Use of GenAI tools will sometimes be in alignment with the learning outcomes for this course. It is expected that the GenAI for this course is very limited. If used, one should follow the fundamental principles of the Honor Code. This includes being honest about the use of these tools for submitted work and including citations when using the work of others, whether individual people or Generative-AI tools. When meeting the outcome requires original human action, creativity or knowledge, AI tool use would not align with the stated course goals.
- **Mason Email Accounts:** Students must use their MasonLive email account to receive important University information, including communications related to this class. I will not respond to messages sent from or send messages to a non-Mason email address. See http://masonlive.gmu.edu for more information on Mason Email System.
- **Office of Disability Services:** If you are a student with a disability and you need academic accommodations, please see me and contact the Office of Disability Services (ODS) at 993-2474. All academic accommodations must be arranged through the ODS, http://ods.gmu.edu.
- **Diversity and Inclusion**: Mason, an intentionally inclusive community, promotes and maintains an equitable and just work and learning environment. We welcome and value individuals and their differences including race, economic status, gender expression and identity, sex, sexual orientation, ethnicity, national origin, first language, religion, age, and disability.
- **Name and Pronoun Use:** If you wish, please share your name and pronouns with me and how best to address you in class and via email. I use he/him/his for myself and you may address me as "Dr./Prof. Yang."

OTHER USEFUL CAMPUS RESOURCES:

- WRITING CENTER: Johnson Center, Room 227E;
  Phone: 703-993-1200; Email: wcenter@gmu.edu; http://writingcenter.gmu.edu
- UNIVERSITY LIBRARIES "Ask a Librarian." http://library.gmu.edu/ask
- Counseling and Psychological Services (CAPS): (703) 993-2380;
  http://caps.gmu.edu

Tentative Schedule:

Tentative Course Schedule (will be changed during the semester. Last modified on August 25, 2023): Please consider this as a list of course contents instead of schedule. The assignment given and due dates will be adjusted accordingly. All efforts will be made to cover as much topics below as possible.

Week 1. Course introduction and introduction to global changes.
- Syllabus overview
- Global mean energy balance
- Factors affecting climate processes
- Greenhouse effect
- Climate modeling
- HW1 (Excel practice on data handling, mean, energy balance) given

Week 2. Data uncertainties.
- Uncertainty concept and error types
- Uncertainty assessment in AR5
- GHG measurements with uncertainties
- Simple statistics for data descriptions
- Paleoclimatic data
- Sampling theory for time series measurements
- HW2 Simple statistics, data list rearrangement, simple plot) given

Week 3. Data model and data formats
- ASCII lists
- Multi-dimensional arrays
- Survey of special data formats for geoscience data (binary, HDF, netCDF, GRIB and BUFR) and available software tools
- HW3 (Time Series basics) given

Week 4. Time Series Basics
- Time Series Types
- Objectives of Time Series Analysis
- Time Series Decompositions
- Stationary Time Series
- HW4 (z score and probabilities in normal distributions) given

Week 5. Basis for Statistical Inference
- Basic ideas
- Sample means
- Hypothesis testing
- Reading assignments: GGS 300 Textbook review
- HW5 given (Confidence interval [CI])

Week 6. Specific Tests for components
- Randomness (turning point test)
- Randomness against trend (difference sign, relative ordering)
- Randomness against trend in seasonal series
- HW6 given (Selected tests for randomness against trend and seasonality)

Week 7. Time series-trend (Shorten week)
- Moving average

- Mid-term

Week 8. Time series-seasonal effects
- HW7&8 (one only) given (climatological and anomaly calculations)

Week 9. Linear regression
- Concept
- Model
- Parameter deduction
- HW9 (Correlation) given

Week 10. Linear regression (Continued)
- Error assessments
- Test for regression
- Test for parameters
- Confidence interval for slope
- HW10 (linear regression concept/calculation/assessment) given

Week 11. Correlation analysis
- Pearson's r
- Other correlation coefficients
- Hypothesis of correlation coefficients
- Relationship between Pearson's r and simple linear regression
- HW11 (linear trends and confidence intervals) given

Week 12. Multiple Linear Regression
- Temporal trend estimate with linear regression
- Models for global temperature
- Linear regression with nonlinear variables
- HW12 (diagnostics of assumptions for linear regressions) given

Week 13. Time series analysis in spectral domain
- Fourier analysis with discrete data
- Response function of temporal filters
- Response function of moving average algorithms
- HW13 (multi-linear regression) given

Week 14. Miscellaneous Topics
- Applications
- Introduction of time-spectral data analysis (wavelets)
- Summary and review
- No HW assignment

Week 15. Final Exam (Thursday, 12/7. All things are due by that date)