GGS 754: Earth Science Data and Advanced Data Analysis
(Updated on Tuesday, January 09, 2024)

Instructor: Ruixin Yang

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Time & Place: Tuesdays, 7:20pm-10:00pm, Exploratory Hall 2310
Office Hours: by appointment.

Text Books (non-standard citation):

- **Text 1 (required)**: Daniel S. Wilks, 1995/2005/2011: "*Statistical Methods in the Atmospheric Sciences: An Introduction*," Academic Press, January 1995 (ISBN: 0127519653); 2nd edition, December 2005 (ISBN-10: 0127519661); 3rd edition (ISBN-13: 978-0123850225); 4th edition, 2020.
- **Text 2 (recommended)**: Hans Von Storch, Francis W. Zwiers, 1999: "Statistical Analysis in Climate Research," Cambridge University Press. Paperback: January 2001. (ISBN: 0521012309); Hardback: January 1999, (ISBN: 0521450713).
- **Text 3 (recommended)**: William J. Emery and Richard E. Thomson, 1998: "Data Analysis Methods in Physical Oceanography," Pergamon, 1998 (ISBN: 0080314341). [2nd Revised Edition (April 2001), Elsevier Health Sciences (ISBN-13: 978-0444507570 for paperback and ISBN-13: 978-0444507563 for hardcover)]. 3rd edition (September 2014, available online) (ISBN-13: 978-0123877826 for paperback).

GMU Catalog Entry:

GGS 754 - Earth Science Data and Advanced Data Analysis (Credits: 3)
Covers accessing and applying Earth observations and remote-sensing data for Earth system science research and applications. Major topics are data formats, analysis and visualization tools, advanced data analysis methods, and data applications. Also covers combining innovative information technology techniques and Earth science data to set up online data centers for accessing data through the web.

Prerequisites
GGS 579 (Remote Sensing) or permission of instructor

Computing Requirements: Programming is an essential part for homework assignments and possibly for the final project. If you do not have any programming experience, you may encounter difficulty to meet the course requirements. It is your choice to use specific programming environment, tools or languages to perform the tasks. Nevertheless, for certain problems such as working with data in special formats, the choice of programming languages and environment may be limited. That means if you are not familiar with the right programming language such as Matlab, you may need to learn it or search for a substitute. Either approach may need substantially extra time. As a result, Matlab and/or IDL/ENVI are highly recommended for this course. Python can also be used for certain data formats such as HDF, netCDF, and GRIB.

Goals and Objectives:

To introduce data, data formats and data analysis methods for earth sciences. Emphasis is on advanced data analysis for time series and spatio-temporal data sets, which are widely used in publications and recently emerged.

Learning Outcomes:

After successful completion of this course,

1. Students will become familiar with earth science data in various formats.
2. Students will understand and utilize data analysis methods for Earth science data analysis.
3. Students will be knowledgeable on certain modern data analysis methods which are potentially useful for earth science data analysis
4. Students will be able to analyze earth science data sets and to write a technical report based on the analysis results.

Course Web Site: Mason Blackboard System

Grading Policy:

Homework Assignments:	50%
Final Project	50%
Total	100% (**Letter grades based on relative numbers)**

General Course Policies

- Attendance will not be considered in the final grade.
- Late assignments will be accepted in the following two days with no penalty. Late assignments beyond 2 days will be accepted and considered for the final grade. However, the late submissions will not be graded as regular submissions.
- Extra credit points may be granted to extra efforts, especially those including creative thinking.

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 Course Contents:

- **This is for your information only for the main contents of the course. Both the contents and the schedule will be changed during the semester.**
- Grayed **materials will not be covered this semester.**

Week 1: Introduction
- Course Requirements
- NASA's Earth Observing Systems (EOS)
- Related URL's
- Theoretical Background: Satellite Orbit Theory

Week 2: Theoretical Background (Continue)
- Satellite Orbit Theory
  - Basics: Newton's laws and Kepler's laws
  - Circular orbits and geostationary orbits
  - Concepts of orbit elements, inclinations
  - Orbit perturbation and Sun-synchronous orbits
  - Space-time samplings
- Radiation Transfer Theory

Week 3: Map Projections
- Basic concepts on distortions, projection planes and projection points
- Classifications
- Earth model and mathematical theory
- Mathematics of specific mappings
- Links
  - USGS Map Projections Poster
  - CMAPF Mapping Routines
  - An example

Week 4: Data Formats
- ASCII
- Binary
- GRIB;
- HDF and HDF-EOS
  - Demos with Grid and Swath Data
- GRIB (short introduction only)
- Assignment #1 given

Week 5: Data Processing Procedures
- Measurements, Nyquist Frequency
- Data Representation
- Multi-variant data presentation
  - Parallel Coordinate
  - Grand Tour
- Tools: GrADS; WebWinds; IDV; CrystalVision

Week 6: Time Series
- Basic Concepts

- TS Components
- General Decompositions
- STL Decomposition
- Assignment #1 due
- Assignment #2 given

Week 7: Time Series (Cont.)

- Autocorrelation
- Correlations
- Assignment #2 due
- Assignment #3 given

Week 8: Time Series (Cont.)

- Regression
- Granger Causality
- Assignment #3 due
- Assignment #4 given

Week 9: Time Series (Cont.)-Integral Transforms

- Fourier Analysis
- Wavelet Analysis

Week 10: Time Series (Cont.)-Integral Transforms

- Wavelet Analysis (Cont.)
- The 2nd Generation Wavelets
- Assignment #4 due
- Project outline due
- Assignment #5 given

Week 11: Time Series (Cont.)

- HOC
- Hilbert-Huang Transformations
- Compressive Sensing

Week 12: Principal Component Analysis

- Assignment #5 due
- Assignment #6 given (optional)

Week 13: Nonlinear Principal Component Analysis

Week 14: Machine Learning (CNN): Idea and Applications

Week 15: Google Earth Engine (GEE) Practice and Applications

Week 16: Introductions on Data Systems

- OPeNDAPS
- SIESIP and GDS
- LAS
- Project Presentation (if arranged)
- Assignment #6 due

Week 17: Final Exam Day (**May 7th**)

- Project Report due
- Project Presentation (if arranged)
- All late HW assignments for consideration due