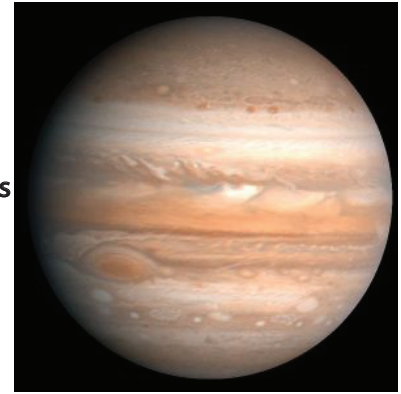


CLIM 411/511  
Introduction to Atmospheric Dynamics



**Catalog Description:** Observational bases and fundamentals of fluid dynamic principles for understanding atmospheric motions across multiple spatial and temporal scales; covers basic conservation laws of mass, momentum, and energy; concepts of circulation and vorticity; balanced atmospheric flows, e.g. geostrophic wind and shear, thermal wind; quasi-geostrophic and isentropic potential vorticity analysis for mid-latitude cyclones and fronts.

**Credits:** 3

**Recommended Prerequisites:** CLIM 111 and MATH 213 (Analytic Geometry & Calculus III), or permission of instructor.

**Time:** 9-10:15am

**Venue:** Exploratory Hall L503

**Instructor:** Natalie Burls

Assistant Professor

Dept. of Atmospheric, Oceanic, & Earth Sciences

<https://cos.gmu.edu/aoes/profile-natalie-burls/>

<https://natalieburls.com/>

**Office Hours:** By appointment (feel free to approach me after class and we will setup a time)

Research Hall, Room 273, Fairfax Campus

Office: (+1) 703-993-5756

Email: nburls@gmu.edu

**Course Objectives:** Students will become familiar with the basic concepts of dynamic meteorology, develop an appreciation of meteorological phenomena across multiple spatio-temporal scales, and be able to apply these concepts to understanding weather and climate phenomena. The course will focus on the following topics:

- Important dynamical balances within atmospheric motion (e.g. geostrophic, hydrostatic, and thermal wind)
- Conservation laws such as energy, mass, momentum, vorticity, and entropy
- Approximations enabling solutions describing the behavior of specific atmospheric phenomenon e.g. the quasigeostrophic equations
- Key structure and development of the mid-latitude weather systems and the related dynamical interpretation.

The CLIM 511 syllabus will follow the same textbook, lecture format and number of homework assignments as the undergraduate, senior-level CLIM 411 class. However, given that CLIM 511 is designed for MSc students typically enrolled in one of the Climate Science MSc concentrations, CLIM

511 students will receive additional, more advanced, questions on each homework assignment, as well as the mid-term and final examinations.

### Important Dates:

Please see the university calendar [[https://registrar.gmu.edu/calendars/spring\\_2022-1/](https://registrar.gmu.edu/calendars/spring_2022-1/)] for drop dates with and without a tuition penalty.

**Grading:** Homework 40%, Mid-term 30%, Final 30%

**Homework:** There are nine homework problem sets. Each set carries 4% of the total grade. Homework problem sets are due one week from when they are assigned. You will also be assigned an in-class rotating tank demonstration (see applicable blackboard assignment for grading rubric) which will form part of your homework grade and carries 4% of your total grade. You will also be asked to complete a class journal and will be assigned bonus points towards your homework grade if you complete these.

### Grade Disputes

Any dispute regarding a grade on any assignment must be made in writing via email within 1-week of receipt of the grade on that assignment.

**Required Textbook:** Martin, Jonathan E., Mid-Latitude Atmospheric Dynamics, John Wiley and Sons, 324pp. It is important that you get this textbook, either hard copy or electronic.

## Syllabus and Schedule

We are going to try something a little different this year to make the class more interactive. I hope to post short videos discussing the class material which follows the textbook chapters very closely (see schedule table below for mapping between content and textbook chapters). You will be expected to watch the assigned video and read the associated textbook pages ahead of each class and come prepared to explain (present) on a given section of it using your notes and the board. We will see how this goes and adjust accordingly.

Lecture	Topic	Textbook Chapter	Homework Assignments	Rotating Tank Demos
Mon 24 <sup>th</sup> Jan	Nature of fluids and useful mathematical tools	1.1-1.5	HW#1	Dye Stirring
Wed 26 <sup>th</sup> Jan	Nature of fluids and useful mathematical tools	1.1-1.5		
Mon 31 <sup>st</sup> Jan	Nature of fluids and useful mathematical tools	1.1-1.5	HW#2	
Wed 2 <sup>nd</sup> Feb	Nature of fluids and useful mathematical tools	1.1-1.5		
Mon 7 <sup>th</sup> Feb	Fundamental forces and apparent forces	2.1-2.2		
Wed 9 <sup>th</sup> Feb	Fundamental forces and apparent forces	2.1-2.2	HW#3	Density Current
Mon 14 <sup>th</sup> Feb	Fundamental forces and apparent forces	2.1-2.2		
Wed 16 <sup>th</sup> Feb	Fundamental forces and apparent forces	2.1-2.2	HW#4	Solid Body Rotation
Mon 21 <sup>st</sup> Feb	Fundamental forces and apparent forces	2.1-2.2		
Wed 23 <sup>rd</sup> Feb	Conservation of momentum, mass and energy	3.1-3.3	HW#5	Fronts
Mon 28 <sup>th</sup> Feb	Conservation of momentum, mass and energy	3.1-3.3		
Wed 2 <sup>nd</sup> Mar	Conservation of momentum, mass and energy	3.1-3.3		
Mon 7 <sup>th</sup> Mar	<b>Midterm</b>			
Wed 10 <sup>th</sup> Mar	Conservation of momentum, mass and energy	3.1-3.3	HW#6	
Mon 14 <sup>th</sup> Mar	<b>Spring Break</b>			

Wed 16 <sup>th</sup> Mar	<b>Spring Break</b>			
Mon 21 <sup>st</sup> Mar	Conservation of momentum, mass and energy	3.1-3.3		
Wed 23 <sup>rd</sup> Mar	Conservation of momentum, mass and energy	3.1-3.3	HW#7	
Mon 28 <sup>th</sup> Mar	Equations of motion and applications	4.1-4.5	Student lecturers	
Wed 30 <sup>th</sup> Mar	Equations of motion and applications	4.1-4.5	Student lecturers	
Mon 4 <sup>th</sup> Apr	Equations of motion and applications	4.1-4.5		Hadley Circulation & Thermal Wind Balance I
Wed 6 <sup>th</sup> Apr	Equations of motion and applications	4.1-4.5	HW#8	Hadley Circulation & Thermal Wind Balance II
Mon 11 <sup>th</sup> Apr	Equations of motion and applications	4.1-4.5		
Wed 13 <sup>th</sup> Apr	Equations of motion and applications	4.1-4.5		Balanced Vortex
Mon 18 <sup>th</sup> Apr	Equations of motion and applications	4.1-4.5		
Wed 20 <sup>th</sup> Apr	Circulation; Vorticity; Potential Vorticity	5.1-5.3	HW#9	
Mon 25 <sup>th</sup> Apr	Circulation; Vorticity; Potential Vorticity	5.1-5.3		Rossby Waves
Wed 27 <sup>th</sup> Apr	Circulation; Vorticity; Potential Vorticity	5.1-5.3		Flow over a Barrier on a Beta Plane
Mon 2 <sup>nd</sup> May	Circulation; Vorticity; Potential Vorticity	5.1-5.3		
Wed 4 <sup>th</sup> May	Quasi-Geostrophic System	5.4		
Mon 16 <sup>th</sup> May	<b>Final Exam</b>	7:30 am – 10:15 am		

### Safe Return to Campus Statement (for students in courses with on-campus meetings)

All students taking courses with a face-to-face component are required to take Safe Return to Campus Training prior to visiting campus. Training is available in Blackboard (<https://mymason.gmu.edu>). Students are required to follow the university's public health and safety precautions and procedures outlined on the university Safe Return to Campus webpage ([www2.gmu.edu/safe-return-plan](http://www2.gmu.edu/safe-return-plan)). Similarly, all students in face to face and hybrid courses must also complete the Mason COVID Health Check daily, seven days a week. The COVID Health Check system uses a color code system and students will receive either a Green, Yellow, or Red email response. Only students who receive a "green" notification are permitted to attend courses with a face-to-face component. If you suspect that you are sick or have been directed to self-isolate, please quarantine or get testing. Faculty are allowed to ask you to show them that you have received a Green email and are thereby permitted to be in class.

### Late Registration and/or Add

Students who register or add the course after the first assignments are due are responsible for making up all materials and assignments that have been missed. The student must:

- a) Meet with the course Instructors and discuss the plans for revised assignment due dates.
- b) Agree *in writing* with the Instructor regarding the due dates for missed assignments.
- c) Failure to do so may result in grading penalties or a zero on missed assignments.

### Accommodations for Disabilities

If you have a documented learning disability or other condition that may affect academic performance you should: 1) contact the Office for Disability Services (SUB I, Rm. 4205; 993-2474; <http://ods.gmu.edu>) to determine the accommodations you need; and 2) talk with me to discuss your accommodation needs.

In addition to providing me with the appropriate form, please take the initiative to discuss accommodation with me at the beginning of the semester and as needed during the term. Because of the range of learning differences, faculty members need to learn from you the most effective ways to

assist you. If you have contacted the Center for Disability Services and are waiting to hear from a counselor, please tell me.

## **Academic Integrity**

GMU is an Honor Code university: It is expected that students adhere to the George Mason University Honor Code as it relates to integrity regarding coursework and grades. The Honor Code reads as follows: "To promote a stronger sense of mutual responsibility, respect, trust, and fairness among all members of the George Mason University community and with the desire for greater academic and personal achievement, we, the student members of the University Community have set forth this: Student members of the George Mason University community pledge not to cheat, plagiarize, steal and/or lie in matters related to academic work." More information about the Honor Code, including definitions of cheating, lying, and plagiarism, can be found at the Office of Academic Integrity website at <http://oai.gmu.edu>

The principle of academic integrity is taken very seriously and violations are treated gravely. What does academic integrity mean in this course? Essentially this: your work is your own, when you are responsible for a task, you will perform that task. When you rely on someone else's work in an aspect of the performance of that task, you will give full credit in the proper, accepted form. Another aspect of academic integrity is the free play of ideas. Vigorous discussion and debate are encouraged in this course, with the firm expectation that all aspects of the class will be conducted with civility and respect for differing ideas, perspectives, and traditions. When in doubt (of any kind) please ask for guidance and clarification.

***Some kinds of participation in online study sites violate the Mason Honor code: these include accessing exam or quiz questions for this class; accessing exam, quiz, or assignment answers for this class; uploading of any of the instructor's materials or exams; and uploading any of your own answers or finished work. Always consult your syllabus and your professor before using these sites.***

## **Privacy**

Students must use their Mason email account to receive important University information, including messages related to this class. See <http://masonlive.gmu.edu> for more information.

## **Campus Closure**

*If the campus closes or class is canceled due to weather or other concern, students should check Blackboard [or other instruction as appropriate] for updates on how to continue learning and information about any changes to events or assignments.*

## **Mason Diversity Statement**

George Mason University promotes a living and learning environment for outstanding growth and productivity among its students, faculty and staff. Through its curriculum, programs, policies, procedures, services and resources, Mason strives to maintain a quality environment for work, study and personal growth.

An emphasis upon diversity and inclusion throughout the campus community is essential to achieve these goals. Diversity is broadly defined to include such characteristics as, but not limited to, race, ethnicity, gender, religion, age, disability, and sexual orientation. Diversity also entails different viewpoints, philosophies, and perspectives. Attention to these aspects of diversity will help promote a

culture of inclusion and belonging, and an environment where diverse opinions, backgrounds and practices have the opportunity to be voiced, heard and respected.

The reflection of Mason's commitment to diversity and inclusion goes beyond policies and procedures to focus on behavior at the individual, group and organizational level. The implementation of this commitment to diversity and inclusion is found in all settings, including individual work units and groups, student organizations and groups, and classroom settings; it is also found with the delivery of services and activities, including, but not limited to, curriculum, teaching, events, advising, research, service, and community outreach.

Acknowledging that the attainment of diversity and inclusion are dynamic and continuous processes, and that the larger societal setting has an evolving socio-cultural understanding of diversity and inclusion, Mason seeks to continuously improve its environment. To this end, the University promotes continuous monitoring and self-assessment regarding diversity. The aim is to incorporate diversity and inclusion within the philosophies and actions of the individual, group and organization, and to make improvements as needed.

### **Sexual Harassment, Sexual Misconduct, and Interpersonal Violence**

George Mason University is committed to providing a learning, living and working environment that is free from discrimination and a campus that is free of sexual misconduct and other acts of interpersonal violence in order to promote community well-being and student success. We encourage students and employees who believe that they have been sexually harassed, sexually assaulted or subjected to sexual or interpersonal misconduct to seek assistance and support. [University Policy 1202: Sexual Harassment and Misconduct](#) speaks to the specifics of Mason's process, the resources, and the options available to students and employees.

***Notice of mandatory reporting of sexual or interpersonal misconduct:*** *As a faculty member, I am designated as a "Non-Confidential Employee," and must report all disclosures of sexual assault, sexual harassment, interpersonal violence, stalking, sexual exploitation, complicity, and retaliation to Mason's Title IX Coordinator per University Policy 1202. If you wish to speak with someone confidentially, please contact one of Mason's confidential resources, such as Student Support and Advocacy Center (SSAC) at 703-380-1434 or Counseling and Psychological Services (CAPS) at 703-993-2380. You may also seek assistance or support measures from Mason's Title IX Coordinator by calling 703-993-8730, or emailing [titleix@gmu.edu](mailto:titleix@gmu.edu).*

### **Useful Campus Resources:**

University Catalog: <http://catalog.gmu.edu/>

University Policies: <http://universitypolicy.gmu.edu/>

Student Support Resources on Campus (<https://ctfe.gmu.edu/teaching/student-support-resources-on-campus>)

Name of Resource	Description of Resource
<a href="#">Assistive Technology Initiative</a>	Manages the production of accessible text for Mason students with disabilities. They also ensure access to information technology and communications to the entire university community through the use of adaptive equipment and provision of technical assistance.



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<a href="#"><u>Center for Academic Advising, Retention, and Transitions</u></a>	Advises students who are thinking about changing majors or who need assistance with their transition to Mason from another institution.
<a href="#"><u>Copyright Resources Office</u></a>	Provides assistance to faculty and students regarding copyright policies.
<a href="#"><u>Counseling and Psychological Services</u></a>	Offers faculty and staff consultation about how to help students that experience difficulties that impact their learning, including how to respond to students in crisis. In particular, the Mason Cares, faculty referral guide, and students of concern are primary resources for faculty and staff. Students can take advantage of psychological services, a variety of learning services, multicultural services, and educational programs that support students' educational goals.
<a href="#"><u>Disability Services</u></a>	Implements and coordinates reasonable accommodations and disability-related services that afford equal access to university programs and activities.
<a href="#"><u>International Programs and Services</u></a>	Provides guidance to students and scholars studying and working at George Mason University on immigration, employment and taxation, and adjustment issues, while fostering cross-cultural understanding through programs highlighting global themes.
<a href="#"><u>Learning Services</u></a>	Provides a variety of experience based learning opportunities through which students explore a wide range of academic concerns. Services include support to students with learning differences, individual study skills counseling, individualized programs of study, and provision of tutoring resources. Presentations on a variety of academic skill topics are available to the university community. The programs are open to all George Mason University students free of charge. Services are confidential and use of these services does not become part of the student's academic record.
<a href="#"><u>Lesbian, Gay, Bisexual, Transgender, Queer, and Questioning Resources</u></a>	Promotes the academic success, health and well-being of lesbian, gay, bisexual, transgender, and queer (LGBTQ) students and their allies. Also works to sustain and strengthen a campus climate of safety, equity, inclusion, and respect in which LGBTQ and ally students can succeed and thrive at Mason.
<a href="#"><u>Mathematics Tutoring Center</u></a>	Offers tutoring on a walk-in basis for all George Mason University students who are enrolled in math courses up to MATH 290.
<a href="#"><u>Military Alliance Program (M.A.P.)</u></a>	Provides faculty and staff participants with an understanding of military students at Mason and how they can be supported. Upon completion of M.A.P. training, participants are certified by the Office of Military Services as a "Military Friendly Staff Member".
<a href="#"><u>Office of Diversity, Inclusion and Multicultural Education (ODIME)</u></a>	Serves students, cultural organizations, and the Mason community by promoting an environment that fosters and values

Name of Resource	Description of Resource
	human understanding and diversity. ODIME seeks to provide services and programs that will instill university-wide appreciation for diverse perspectives and ensure equal levels of inclusion, participation, and retention of underrepresented student groups in their quest for a quality.
<a href="#"><u>Office of the Ombudsman</u></a>	Acts as a unique resource for students to discuss concerns and complaints and serves as a safe space to facilitate the resolution of conflicts. As an impartial party, the office does not take sides in any conflict and operates independently of any formal channels at the university.
<a href="#"><u>Safe Zone</u></a>	Creates a safer, more welcoming and inclusive campus environment to strengthen community and encourage networking among faculty, staff, and students toward the goal of supporting the well-being of LGBTQ people.
<a href="#"><u>Social Action and Integrative Learning (SAIL)</u></a>	Fosters experiential learning opportunities on campus, regionally, and globally for the Mason community with a particular emphasis on effecting positive social change. SAIL is Mason's home for service-learning initiatives.
<a href="#"><u>Student Conduct</u></a>	Provides information about university policies, the student conduct process, and resources for faculty related to addressing student behaviors of concerns and other disruptive behaviors.
<a href="#"><u>Student Health Services</u></a>	Provides high quality health care, counseling, education, and prevention services in support of student learning and retention.
<a href="#"><u>Student Support and Advocacy Center</u></a>	Provides comprehensive services for students in an effort to foster the safety and well-being of the Mason community. SSAC services include assisting students who are encountering barriers to their academic success or personal growth, interpersonal violence prevention, alcohol and drug education, health promotion/healthy relationships, student crisis intervention, and connecting students with appropriate campus and off-campus resources.
<a href="#"><u>UNIV Courses and Programs</u></a>	Serves as a resource and development center for undergraduates, providing courses, programs, and services to facilitate students' personal and academic success.
<a href="#"><u>University Career Services</u></a>	Provides information on career choices, internships and employment, and graduate and professional school.
<a href="#"><u>University Life</u></a>	Enhances students' in- and out-of-class experiences, in addition to facilitating interactions among faculty, staff, and other students. These resources help students achieve academically, stay healthy, get involved with campus life, find jobs, and identify resources to enrich their learning.
<a href="#"><u>University Writing Center</u></a>	Offers both in-person and online writing assistance for students, including online writing guides, reference guides, and style manuals. Additionally, the Writing Center provides assistance to

Name of Resource	Description of Resource
	faculty who are interested in holding in-class writing workshops, developing effective writing assignments, or evaluating students' writing.