Regional-Scale Numerical Weather Prediction
ATMO 5332
Fall 2022

General Information

Meeting time: T/Th 2:00 - 3:20
Classroom: MCOM 253
Instructor: Dr. Brian Ancell
Office: MCOM 1216
Office Hours: T/Th 3:30 – 4:30 (or by appointment)
Email: Brian.Ancell@ttu.edu
Phone: 834-3143
Class website: http://www.atmo.ttu.edu/bancell/atmo5332.html
Textbook: None required
Reference Books:
1) *Numerical Methods for Wave Equations in Geophysical Fluid Dynamics*, Durran, 1999
2) *Fundamentals of Atmospheric Modeling*, Jacobson, 1999
3) *Mesoscale Meteorological Modeling*, Pielke, 2002
4) *Parameterization Schemes – Keys to Understanding Numerical Weather Prediction Models*, Stensrud, 2007
5) *Atmospheric Modeling, Data Assimilation, and Predictability*, Kalnay, 2003
6) *Elementary Differential Equations and Boundary Value Problems*, Boyce and DiPrima, 2001
7) *Forecast Verification – A Practitioner's Guide in Atmospheric Science*, Jolliffe and Stephenson, 2003
8) *Dynamical Data Assimilation: A Least Squares Approach*, Lewis, Lakshmivarahan, and Dhall, 2006

Course Description

Numerical weather prediction (NWP) is important for a variety of applications ranging from day-to-day forecasting guidance to things like wind power and fire weather prediction. This course addresses three general questions regarding NWP – 1) How does an NWP model work? 2) How does one measure the success of an NWP model? 3) How predictable is the atmosphere? To answer the above questions, the following specific topics will be covered in this class:

How does an NWP model work?

1) Time-stepping and spatial discretization techniques and their accuracy
2) Numerical stability
3) The governing equations
4) Parameterization schemes
5) Limited-area models and their boundary conditions
6) NWP coordinate systems
7) Computing demands

How does one measure the success of an NWP model?

1) Forecast verification
2) Model bias
3) Model Output Statistics (MOS)

How predictable is the atmosphere?

1) Chaos in NWP
2) Model error and the attractor
3) Ensemble and deterministic prediction
4) Data assimilation
5) Sensitivity analysis

In addition, students will conduct a class project involving a modeling study of their choice using the Weather Research and Forecasting (WRF) NWP mesoscale model. Details of this project will be provided later in the semester.

Expected Learning Outcomes

Upon completion of this course, students should be able to:

1. Understand how an NWP model is configured and run to solve the differential equations governing the atmosphere to produce a forecast.
2. Utilize basic forecast verification techniques to evaluate NWP model forecasts.
3. Understand the predictability of the atmosphere and methods developed to address predictability such as ensemble forecasting and data assimilation.
4. Run the WRF model and analyze its output.

Methods for Assessing Learning Outcomes

The expected learning outcomes will be assessed through following:
1. 2 graded homework assignments (15% each)
2. 2 exams (25% each)
3. Project with oral presentation (20%)

Grading Scale

A = 90 or above
B = 80-90
C = 70-80
D = 60-70
F = below 60

Class Attendance

Class attendance is highly encouraged but no method of taking attendance is used. Class notes should be obtained from fellow students for missed lecture material.

Students with Disabilities

Any student who, because of a disability, may require special arrangements in order to meet the course requirements should contact the instructor as soon as possible to make any necessary arrangements. Students should present appropriate verification from Student Disability Services during the instructor's office hours. Please note: instructors are not allowed to provide classroom accommodations to a student until appropriate verification from Student Disability Services has been provided. For additional information, please contact Student Disability Services in West Hall or call 806-742-2405.

Academic Integrity

Academic integrity is taking responsibility for one's own class and/or course work, being individually accountable, and demonstrating intellectual honesty and ethical behavior. Academic integrity is a personal choice to abide by the standards of intellectual honesty and responsibility. Because education is a shared effort to achieve learning through the exchange of ideas, students, faculty, and staff have the collective responsibility to build mutual trust and respect. Ethical behavior and independent thought are essential for the highest level of academic achievement, which then must be measured. Academic achievement includes scholarship, teaching, and learning, all of which are shared endeavors. Grades are a device used to quantify the successful accumulation of knowledge through learning. Adhering to the standards of academic integrity ensures grades are earned honestly. Academic integrity is the foundation upon which students, faculty, and staff build their educational and professional careers. [Texas Tech University ("University") Quality Enhancement Plan, Academic Integrity Task Force, 2010].

Religious Holy Days

"Religious holy day" means a holy day observed by a religion whose places of worship are exempt from property taxation under Texas Tax Code §11.20. A student who intends to observe a religious holy day should make that intention known in writing to the instructor prior to the absence. A student who is absent from classes for the observance of a religious holy day shall be allowed to take an examination or complete an assignment scheduled for that day within a reasonable time after the absence. A student who is excused under section 2 may not be penalized for the absence; however, the instructor may respond appropriately if the student fails to complete the assignment satisfactorily.

Discrimination, Harassment, and Sexual Violence

Texas Tech University is committed to providing and strengthening an educational, working, and living environment where students, faculty, staff, and visitors are free from gender and/or sex discrimination of any kind. Sexual assault, discrimination, harassment, and other Title IX violations are not tolerated by the University. Report any incidents to the Office for Student Rights & Resolution, (806)-742-SAFE (7233) or file a report online at titleix.ttu.edu/students. Faculty and staff members at TTU are committed to

connecting you to resources on campus. Some of these available resources are: TTU Student Counseling Center, 806- 742-3674, https://www.depts.ttu.edu/scc/(Provides confidential support on campus.) TTU 24-hour Crisis Helpline, 806-742-5555, (Assists students who are experiencing a mental health or interpersonal violence crisis. If you call the helpline, you will speak with a mental health counselor.) Voice of Hope Lubbock Rape Crisis Center, 806-763-7273, voiceofhopelubbock.org (24-hour hotline that provides support for survivors of sexual violence.) The Risk, Intervention, Safety and Education (RISE) Office, 806-742-2110, https://www.depts.ttu.edu/rise/ (Provides a range of resources and support options focused on prevention education and student wellness.) Texas Tech Police Department, 806-742- 3931, http://www.depts.ttu.edu/ttpd/ (To report criminal activity that occurs on or near Texas Tech campus.)

Civility in the Classroom

Texas Tech University is a community of faculty, students, and staff that enjoys an expectation of cooperation, professionalism, and civility during the conduct of all forms of university business, including the conduct of student–student and student–faculty interactions in and out of the classroom. Further, the classroom is a setting in which an exchange of ideas and creative thinking should be encouraged and where intellectual growth and development are fostered. Students who disrupt this classroom mission by rude, sarcastic, threatening, abusive or obscene language and/or behavior will be subject to appropriate sanctions according to university policy. Likewise, faculty members are expected to maintain the highest standards of professionalism in all interactions with all constituents of the university (www.depts.ttu.edu/ethics/matadorchallenge/ethicalprinciples.php).

Plagiarism

Texas Tech University expects students to "understand the principles of academic integrity and abide by them in all class and/or course work at the University" (OP 34.12.5). Plagiarism is a form of academic misconduct that involves (1) the representation of words, ideas, illustrations, structure, computer code, other expression, or media of another as one's own and/or failing to properly cite direct, paraphrased, or summarized materials; or (2) self-plagiarism, which involves the submission of the same academic work more than once without the prior permission of the instructor and/or failure to correctly cite previous work written by the same student. This video, retrieved from the University of Kansas Libraries website, provides an example of a plagiarism definition as well as examples of plagiarism and how to avoid it. Please review Section B of the TTU Student Handbook for more information related to other forms of academic misconduct, and contact your instructor if you have questions about plagiarism or other academic concerns in your courses. To learn more about the importance of academic integrity and practical tips for avoiding plagiarism, explore the resources provided by the TTU Library and the School of Law.

LGBTQIA Support Statement

Office of LGBTQIA, Student Union Building Room 201, www.lgbtqia.ttu.edu, 806.742.5433

Within the Center for Campus Life, the Office serves the Texas Tech community through facilitation and leadership of programming and advocacy efforts. This work is aimed at strengthening the lesbian, gay, bisexual, transgender, queer, intersex, and asexual (LGBTQIA) community and sustaining an inclusive campus that welcomes people of all sexual orientations, gender identities, and gender expressions.

Food Insecurity

Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact the Dean of Students for support. Furthermore, please notify the professor if you are comfortable in doing so. The TTU Food Pantry is in Doak Hall 117. Please visit the website for hours of operation at https://www.depts.ttu.edu/dos/foodpantry.php.

COVID-19 Information

The University will continue to monitor CDC, State, and TTU System guidelines concerning COVID-19. Any changes affecting class policies or temporary changes to delivery modality will be in accordance with those guidelines and announced as soon as possible. Students will not be required to purchase specialized technology to support a temporary modality change, though students are expected to have access to a computer to access course content and course-specific messaging.

This is where students can find information about COVID testing, vaccinations, isolation, and quarantine. https://www.depts.ttu.edu/communications/emergency/coronavirus/.

If you test positive for COVID-19, report your positive test through TTU's reporting system: https://www.depts.ttu.edu/communications/emergency/coronavirus/. Once you report a positive test, the portal will automatically generate a letter that you can distribute to your professors and instructors.

Schedule

The following schedule is an estimate and subject to change.

8/25	Class introduction, HPCC account information
8/30	Time-stepping schemes
9/1	Time-stepping schemes
9/6	WRF model tutorial
9/8	Spatial discretization
9/13	Stability analysis, chaos seeding

9/15	The governing equations
9/20	Vertical coordinates, map projections
9/22	Parameterization schemes
9/27	Parameterization schemes, forecast verification
9/29	Forecast verification, predictability and chaos
10/4	Exam #1
10/6	Predictability and chaos
10/11	Go over Exam #1
10/13	Singular vectors
10/18	Adjoint sensitivity analysis
10/20	Ensemble prediction
10/25	Ensemble prediction
10/27	Ensemble sensitivity analysis
11/1	Data assimilation
11/3	Kalman filter/ensemble Kalman filter
11/8	Variational schemes
11/10	Adaptive data assimilation
11/15	Adaptive data assimilation
11/17	Exam #2
11/22	Go over exam #2
11/24	No class, Thanksgiving holiday
11/29	Project presentations
12/1	Project presentations
12/6	Project presentations