GEOGRAPHY 5941
SYNOPTIC ANALYSIS AND WEATHER FORECASTING
AUTUMN SEMESTER 2020

Instructor: Jeff Rogers, Professor Emeritus Office: Derby Hall 1085
Office Hours: just before class, by appointment, or by e-mail: rogers.21@osu.edu
Class times: T, Th 11:10 – 12:30 p.m. DB140 either in-person or virtually
Prerequisites: Geography 5900, Geography 5940, Math 1152, Physics 1251.
Course Website: http://carmen.osu.edu for syllabus, lecture pdf's, assignments & announcements

Course Objectives: The primary objective of this course is to serve as an introduction to the fundamentals of, and techniques involved in, synoptic-scale analysis of winter storms and the forecasting of their weather. Discussion of the fundamentals of weather forecasting includes understanding the physical models available to analyze synoptic-scale weather patterns, evaluation of the physical processes that create temperature change, vertical motions, precipitation, and those processes that lead to cyclones and fronts, causing them to evolve and produce weather. Techniques of synoptic weather analysis revolve around weather maps and methods used to analyze them to predict horizontal and vertical motions and make weather forecasts. Analysis of forecast output will be evaluated to compare precipitation and vertical motion forecasts among different models.

Upon successful completion of the course, students will be able to use synoptic weather charts and numerical forecasting products in order to acquire skills needed to make competitive weather forecasts of temperature, precipitation and other meteorological conditions for 1-2 days in advance. You will have a good understanding of the conceptual models of wave cyclones, including those of their structure and evolution, and you will be able to explain the role of various physical processes, such as PVA, thermal advection, atmospheric stability, and diabatic heating, in the development and evolution of mid-latitude wave cyclones.

Your total grade (100%) will be determined as follows:
Mid-term exam: 30% 2nd exam: 30% Assignments: 40%
Option 1: exams on ~ October 15 and on November 24, *if classes remain partially in-person*. Virtual assignments or lectures on December 1 & 3. No final exam.
Option 2: exam on ~ October 15 and a final exam some day during Finals week, *if the university closes in-person classes much earlier than Thanksgiving*.
Other options may evolve as events unfold during the semester.
Course lectures will be recorded on zoom & one of the two student cohorts will be watching live. Standard "take-home" and "in-class" assignments might be paper exchanges but most likely they will be handled electronically. Grading may be optional sometimes, although I will always provide answers and consider using similar assignment concepts on exams.
We have one large semester-long assignment: virtual participation in the University of Oklahoma National Weather Forecast Contest. This will account for 15% of your total grade and therefore about 40% of your assignment grade. We follow Oklahoma's rules (with a couple of exceptions described later) and I grade the results as an assignment. Student grades will range from A to C- (lower with extensive failure-to-participate). The contest/assignment requires electronic

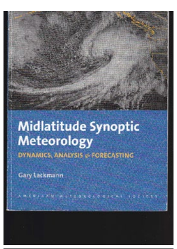
submission of a forecast every Monday through Thursday from late September onward by 8:00 p.m. EDST (later 7:00 p.m. EST). Participation is mandatory and will cost $3.

Assignments must be done individually unless it is announced that the assignment is a group effort. Proof of a medical problem is necessary to excuse an absence on an exam day.

Important Dates: The last in-person day is November 25, Wednesday.
Virtual classes November 30 through December 4 including Dec. 1 & 3 (T, TH) for this class.
University Official Final Exam dates are December 7-11.

Health and safety requirements: All students, faculty and staff are required to comply with and stay up to date on all university safety and health guidance (https://safeandhealthy.osu.edu), which includes wearing a face mask in any indoor space and maintaining a safe physical distance at all times. Non-compliance will be warned first and disciplinary actions will be taken for repeated offenses.

COVID-19 accommodations through SLDS: The university strives to make all learning experiences as accessible as possible. In light of the current pandemic, students seeking to request COVID-related accommodations may do so through the university's request process, managed by Student Life Disability Services. If you anticipate or experience academic barriers based on your disability (including mental health, chronic, or temporary medical conditions), please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. SLDS contact information: slds@osu.edu; 614-292-3307; slds.osu.edu; 098 Baker Hall, 113 W. 12th Avenue.



Recommended book:
by Gary Lackmann, not required, but the best synoptic book in decades

Final Examination scheduled: Tuesday December 8, 2020; Noon - 1:45 p.m. in Derby 140. This final exam date and time may or may not be observed, as described above.

Lecture Outline: Following below is a lecture outline for this Geog./Atmos. Sci. 5941 reorganized and revised Synoptic Meteorology course that is currently complete through Lecture 17.

Geog. / Atmos. Sci. 5941: Synoptic Meteorology Course Topics Outline

Lecture #. Title, followed by subsections

1. History of Meteorology & Weather Forecasting
    - Ancient Meteorology
    - Nineteenth Century Meteorology
    - Thermal theory
    - Bergen School: the model, members and legacy
1. Physical Geography factors in No. Am. weather
2. Atmospheric Heat Transfer & the Mean State of the atmosphere
    - Energy types and earth response to solar & IR
        - TPE, ZAPE, EAPE
    - Atmos Heat Transport tropics & mid-Lats
        - APE to Kinetic energy conversion in the tropics & mid-lats
        - Baroclinic instability & mid-latitude heat transfer
    - Mean State of the upper atmosphere: standing waves
        - Standing wave "centers of action" at the surface
3. Air Masses
    - Air Mass types and stability
    - Air Mass Modification
    - Air mass parcel trajectories
3. Upper Air Rossby waves
    - Long Waves, streamlines
    - Short (transient) Waves, stable & unstable
4. Equations of Motion & Gradient wind
    - Wind in Cartesian & Natural Coordinates
    - (Momentum) Equations of motion
    - Gradient and Geostrophic winds
    - Ageostrophic winds and vertical motion
            - Gravity waves and geostrophy
    - Atmospheric scales of motion
        - Synoptic scale and mesoscale-alpha
    - Quasi-geostrophic theory premise and benefits
5. Hypsometric Equation and Thickness
    - 3^{rd} eq motion and hydrostatic equilibrium
        - Geopotential and geopotential meters
    - Equation of state & virtual temperature
    - Hypsometric equation
    - Tropospheric thickness
        - Thickness on weather charts
        - Four basic vertical structures
6. Thermal wind and Jet Streams
    - Thermal wind, its vector representation and thermal advection
        - Thermal wind vectors and thermal heat advection
            - Veering, backing winds
    - Baroclinic and Barotropic Atmospheres
    - Jet streams in the upper air westerlies
        - Jet Stream seasonality and geographic variation
        - African easterly jet
        - Climate change and jet streams
    - Forecasting Issues and jet streams
        - Mid-latitude air
        - Do jet streams cause the weather

7. The First Law & Air Temperature Forecasting
    - First Law of Thermodynamics & the Thermodynamic Energy Equation
    - Advection, adiabatic and Diabatic processes in temperature forecasting
    - Modifying MOS temperature forecasts

8. Divergence, Vorticity and Vertical Motions
    - Equation of mass continuity leading to divergence
    - 3 Causes of Ageostrophic motions
        - Friction, curvature, df/dy
    - Ageostrophic motions
    - Relative and Absolute vorticity definitions
    - Vorticity (tendency) equation and relation to divergence
    - CAV trajectories (why Rossby waves exist at all)
    - Rossby wavelength and divergence strength

9. QG Vertical Motions on Synoptic Weather Charts
    - QG Omega equation
    - Analysis of Thermal advection & vertical motion
        - Thermal Advection vectors and TA solenoids
    - Divergence, linking Rossby waves & surface systems
        - Divergence analyses on weather maps
    - Vorticity Advection Analysis on weather charts
        - PVA, NVA, and DPVA

10. QG diagnostics of Synoptic weather systems
    - Pressure Tendency Equation
        - Derivation & interpretation of constituent terms
        - Surface system deepening, weakening, and motion
            - Lists: factors causing pressure falls; vertical motion proxies; divergence
    - QG Omega Equation and DPVA
    - Diagnostics of wx systems with QG Height tendency equation
        - PVA, height falls, vertical motions & adiabatic heating/cooling
            - Surface cyclogenesis in baroclinic zones and PVA
            - Digging, Lifting troughs aloft
            - Differential thermal advection & height tendency

11. Equivalent Barotropic & Baroclinic wx systems
    - Barotropic atmospheres
    - Equivalent Barotropic systems and their wind vectors
        - Features: occlusions, cut-off low, polar lows, warm-core lows
            - Blocking high, cut-off Highs, plateau high, warm-core Highs
    - Baroclinic atmosphere
        - Baroclinic wx system features
        - Baroclinic Highs

12. Baroclinic Instability & Self-development of cyclones
    - Baroclinic Lows: their structure and weather
    - Brief overview Norwegian cyclone model
    - Baroclinic Instability Process
        - Minimum requirements for Baroclinic Instability
        - Changes in wave tilt, amplitude, length, & jet stream
    - Self-development of cyclones
        - Feedback between thermal advection and vorticity advection
        - What stops Instability/self-development?

13. Conservation of potential vorticity
    - Static stability and vorticity change
    - Lee trough cyclogenesis
    - Polar outbreaks and air mass evolution

13. Jet Streaks

- Jet Streak PVA centers and ageostrophic motions
- Jet entrance region dynamics and stability changes
- Satellite observed transverse cloud bands due to jet streaks

14. Diabatic heating and instability in U.S. East Coast & Clipper storms
    - Role of vertical lift of stable & unstable air
        - Latent heat release and meteorological bombs
    - Role of diabatic heating
    - Examples of cyclogenesis over North America
        - East Coast storms
            - Cold air damming & coastal fronts
            - Jet strak interaction in east coast snowstorms
        - Rocky Mtn lee storms, panhandle hook & Alberta Clipper
15. Winter Precipitation, Fog & Wind Forecasting
    - Heavy snow forecasting
    - Precipitation type (mixed precip.) forecasting
    - Fog types & Fog forecasting
    - Wind forecasting and causes of turbulence
16. Frontal Characteristics and Frontogenesis
    - Density differences across fronts
    - 7 major Frontal Characteristics
        - Frontal slope importance and how to determine
16. Frontogenesis, overview and math
    - 5 processes leading to frontogenesis
        - Pressure field deformation zones & frontogenesis
    - Ageostrophic motions across fronts during frontogenesis
17. Weather system clouds from Satellite Analysis
    - Baroclinic Cirrus Shields (BCS)
    - Deformation Zone cloud bands
        - Large-scale commas linked by BCS & DZ cloud bands
    - Vorticity Commas
        - Polar lows (Arctic hurricanes)
17. Atmospheric Conveyor Belts
    - Warm conveyor east of Rossby wave troughs (baroclinic cirrus shield)
    - Cold conveyor and the deformation zone under warm fronts
    - The Dry conveyor descending west of Rossby wave troughs
            - Cold, dry, descent and baroclinic instability
            - Dry descent leading to dry slots on large-scale comma
18. Fronts, their characteristics and weather
    - Cold Front Aloft
    - Surface Cold Front
        - Anafront & Katafront
    - Warm fronts
    - EML front
    - Coastal Front
    - Occluded fronts
19. The Shapiro Keyser Cyclone Model
    - Norwegian cyclone model final stages
        - The seclusion, seclusions over Ohio
        - The cold are warm types occlusions
        - Bergen Cyclone model critical problems
    - The Shapiro-Keyser cyclone component features
        - Frontal fracture and T-bone bent-back warm fronts
        - The warm air seclusion, revisited
        - The Sting Jet and synoptic-scale weather catastrophes

Occlusion, revisited
20. Plains Cyclone Model; The North American Blizzard