SIO 217B (Winter 2019)

Atmospheric and Climate Sciences II: Atmospheric Dynamics

Instructor: Shang-Ping Xie, (office) MESOM 323, (email) sxie@ucsd.edu, (phone) 858-822-0053

Date, time, location: Tuesdays and Thursdays, 11:00-12:20, Spiess Hall 330

Synopsis: On the California coast, summer is dry and kept cool by the northerly winds and the ocean upwelling they induce. In winter, successive rain storms come ashore from the North Pacific Ocean riding on the westerly winds. The westerly winds aloft do not merely steer these storms eastward but cause some of these storms to wax and some to wane. The development of dynamical meteorology over the 20th century led to physical insights into how winter storms grow, move and decay, culminating into operational numerical weather prediction on which the public is dependent. This class surveys atmospheric dynamics that governs the large-scale flow and the variations. This subject is unavoidably mathematical, and you will need to develop (or already have) familiarity with aspects of vector calculus and partial differential equations.

Learning objectives: Students will know how to derive and interpret governing equations for large-scale flow, understand fundamental concepts (e.g., geostrophic and thermal winds, vorticity, potential vorticity, quasi-geostrophic approximation, and Rossby waves), and apply them to interpreting large-scale wind variations.

Office Hours: Students are welcome to stop by my office anytime. One ideal time is right after class. You can also make an appointment.

Grading: 50% homework, 40% final exam, and 10% participation.

Homework: This material is best learned by working through problems, and problem sets will be assigned approximately once per week. Homework will be graded, and each student's lowest homework grade will be dropped in the calculation of the final grade. Students are encouraged to work together on homework exercises as long as each student turns in only his or her own work. Please do not consult homeworks or solutions from previous years.

Exam: Final exam is 1130am-230pm, March 14 (Th).

Textbook: *An Introduction to Dynamic Meteorology, Fourth Edition*, by J.R. Holton (2004) [here].

Other textbooks covering aspects of the material we cover that you may also find useful:

Mid-Latitude Atmospheric Dynamics by Jonathan Martin (2006) [here]: Detailed derivations and applications to mid-latitude synoptic cyclones, e.g., chapter 6 "Diagnosis of vertical motions."

Global Physical Climatology by Dennis Hartmann (1994) [here]

Atmosphere-Ocean Dynamics by Adrian Gill (1982) [here]: Comprehensive dynamics, especially regarding waves; nice discussion of the boundary wave, Rossby height, and Eady problem of baroclinic instability (sections 13.2-3)

An Introduction to Dynamic Meteorology, Fifth Edition, by J.R. Holton and G.J. Hakim (2012): with enhanced discussion of observations.

Lectures and assignments *(evolving)*

Lecture schedule:

- Tue 1/08: Introduction (read textbook sections 1.1-1.2, 1.6.1), basic forces (1.4). Read also section 1.2.1 of J. Martin's text for a useful review of vector calculus.
- Thu 1/10: Coriolis force (1.4, 1.6.1, 1.5)
- Tue 1/15: Material derivative, momentum equation (2.1-2.4, 1.3)
- Thu 1/17: Continuity equation, energy equation (2.5-2.6)
- Tue 1/22: Potential temperature, static stability (2.7)
- Thu 1/24: Isobaric coordinates, summary of governing equations (2.7, 1.6.2, 3.1)
- Tue 1/29: Geostrophic flow & gradient wind (3.2)
- Thu 1/31: Trajectories, thermal wind, westerly jet stream (3.3-3.4)
- Tue 2/05: Vertical motion (3.5), circulation (4.1)
- Thu 2/07: Vorticity (4.2, 4.4)
- Tue 2/12: Barotropic potential vorticity (PV) (4.3, 4.5)
- Thu 2/14: Baroclinic potential vorticity (4.3)
- Tue 2/19: Waves, dispersion relationship, phase & group velocities (7.1-7.2)
- Thu 2/21: Barotropic Rossby waves, stationary waves in a zonal channel (7.7) & on a sphere (10.5.1)
- Tue 2/26: Quasi-geostrophic (QG) approximation (6.1-6.2)
- Thu 2/28: QG PV equation, PV inversion, Rossby height (6.3)
- Tue 3/05: QG vertical motion, Q vector (6.4)
- Thu 3/07: 2-level model, baroclinic Rossby waves (8.2), Rossby radius of deformation, South Asian monsoon high
- Tue 3/12: Cyclogenesis, baroclinic instability (8.1-8.2)
- Thu 3/14: Review
- Thu 3/21: Final exam (calculator and a letter-size sheet are allowed).

Lecture notes: Will be posted after each lecture on TritonEd.ucsd.edu

Homework assignments: