

MIDDLE ATMOSPHERE DYNAMICS

ATS 708 (3 credits)

Spring 2014

Instructor: Thomas Birner

Meeting Times: MW 11-12:15 in ATS 101

Prerequisites: AT602 (C/WI)

Class Website: <http://birner.atmos.colostate.edu/ats708.html>

Course Description: Dynamics of the stratosphere and mesosphere with emphasis on the lower and middle stratosphere (below about 5 hPa). A range of topics will be outlined after the introductory lectures at the end of the first week of the course. A subset of topics to be covered will be selected by the students. Lead-in lectures will be given to each of those selected topics by the instructor and will be alternated with student presentations of assigned specific topics (usually 1–3 papers or a term project). A list of relevant papers to each topic will be provided by the instructor, however, students are encouraged to do some literature search on their own. Current stratospheric "weather" (polar vortex evolution) will be discussed once a week. Grades will be based on student presentations (33%), corresponding written notes (33%), and participation in class discussion (33%).

At least 2 hours of effort are expected to complete readings and homework assignments outside of class for each hour of class time.

This course will adhere to the CSU Academic Integrity Policy as found in the General Catalog (<http://www.catalog.colostate.edu/FrontPDF/1.6POLICIES1112f.pdf>) and the Student Conduct Code (<http://www.conflictresolution.colostate.edu/conduct-code>). At a minimum, violations will result in a grading penalty in this course and a report to the Office of Conflict Resolution and Student Conduct Services.

Relevant Textbooks & Monographs:

- *Middle Atmosphere Dynamics*, 1987, Andrews, Holton, Leovy, Academic Press.
- *Atmospheric and Oceanic Fluid Dynamics*, 2006, Vallis, Cambridge University Press. (Chs. 7, 12, 13)
- *Aeronomy of the Middle Atmosphere – Chemistry and Physics of the Stratosphere and Mesosphere*, 2005, Brasseur and Solomon, Springer.
- *The Stratosphere – Phenomena, History, Relevance*, 1999, Labitzke and van Loon, Springer.
- *The Stratosphere: Dynamics, Transport, and Chemistry*, 2010, AGU Monograph 190 (Plumb Festschrift, Eds. Polvani, Sobel, Waugh)

Various Relevant Review Articles (alphabetically):

- Baldwin et al., 2001: The quasi-biennial oscillation. *Rev. Geophys.*, **39**, 1979–229.
- Fritts, D. C. and M. J. Alexander, 2003: Gravity wave dynamics and effects in the middle atmosphere. *Rev. Geophys.*, **41**, 1003.
- Fueglistaler et al., 2009: Tropical tropopause layer. *Rev. Geophys.*, **47**, RG1004.
- Gettelman et al., 2011: The extratropical upper troposphere and lower stratosphere. *Rev. Geophys.*, **49**, RG3003.
- Haynes, P. H., 2005: Stratospheric Dynamics. *Annu. Rev. Fluid Mech.*, **37**, 263–293.
- Holton, J. R., Haynes, P. H., McIntyre, M. E., Douglass, A. R., Rood, R. B., Pfister, L., 1995: Stratosphere–Troposphere Exchange. *Rev. Geophys.*, **33**, 403–439.
- Plougonven, R. and F. Zhang, 2014: Internal gravity waves from atmospheric jets and fronts. *Rev. Geophys.*, in press.
- Plumb, R. A., 2002: Stratospheric Transport. *J. Meteorol. Soc. Japan*, **80**, 793–801.
- Plumb, R. A., 2007: Tracer Interrelationships in the Stratosphere. *Rev. Geophys.*, **45**, RG4005.
- Shepherd, T. G., 2002: Issues in Stratosphere–Troposphere Coupling. *J. Meteorol. Soc. Japan*, **80**, 769–792.
- Shepherd, T. G., 2007: Transport in the Middle Atmosphere. *J. Meteorol. Soc. Japan*, **85B**, 165–191.
- Waugh, D. W. and T. M. Hall, 2002: Age of stratospheric air: theory, observations, and models. *Rev. Geophys.*, **40**, 1010.

Topics

1. Vertically Propagating Waves
 - extratropical Rossby waves and Charney-Drazin criterion
 - equatorial waves
 - gravity waves
2. Wave–Mean Flow Interaction
 - non-acceleration theorem(s)
 - Transformed Eulerian Mean Formulation
 - isentropic coordinates
 - Downward Control Principle
3. Sudden Stratospheric Warmings
4. Rossby Wave Breaking
 - surf zone
5. Large–Scale Mixing and Transport
 - Age of Air diagnostic
 - effective diffusivity
 - (leaky) mixing barriers
6. Brewer–Dobson Circulation, Residual (Diabatic) Circulations
 - shallow vs. deep circulation branch
 - stratospheric vs. mesospheric circulation
7. Tropical Tropopause Layer
 - Dehydration and Troposphere-to-Stratosphere Transport
 - Dynamics of tropical upwelling
8. Extratropical Stratosphere-Troposphere Exchange
9. Tropopause Dynamics
10. Quasi–Biennial Oscillation (QBO)
11. Stratosphere-Troposphere Coupling
12. Solar Influences on Climate ‘top-down’
13. Climate Change in the Middle Atmosphere