MIDDLE ATMOSPHERE DYNAMICS

AT707 (3 credits)

Spring 2009

Instructor: Thomas Birner

Meeting Times: Twice per week (for 1:15 hours)

Prerequisites: AT602, AT605 (P/WI)

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 within the given semester 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). 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. Grades will be based on paper presentations (40%), corresponding written notes (40%), and participation in class discussion (20%).

Relevant Textbooks:

- *Middle Atmosphere Dynamics*, 1987, Andrews, D. G., Holton, J. R., Leovy, C. B., Academic Press, 489 pp.
- *Atmospheric and Oceanic Fluid Dynamics*, 2006, Vallis, G. K., Cambridge University Press, 745 pp.
- *Aeronomy of the Middle Atmosphere – Chemistry and Physics of the Stratosphere and Mesosphere*, 2005, Brasseur, G. P. and Solomon, S., Springer, 646 pp.
- *The Stratosphere – Phenomena, History, Relevance*, 1999, Labitzke, K. G. and van Loon, H., Springer, 179 pp.

Recent Review Articles:

- Haynes, P. H., 2005: Stratospheric Dynamics. *Annu. Rev. Fluid Mech.*, **37**, 263–293.
- Plumb, R. A., 2007: Tracer Interrelationships in the Stratosphere. *Rev. Geophys.*, in press.
- Shepherd, T. G., 2007: Transport in the Middle Atmosphere. *J. Meteorol. Soc. Japan*, **85B**, 165–191.

Outline

1. Introduction
    - 1.1 Climatology (Temperature, Wind, Chemical Tracers)
    - 1.2 Overview of Stratospheric and Mesospheric Phenomena
    - 1.3 Review of "Potential Vorticity Thinking"
    - 1.4 Basic Radiation
2. Vertically Propagating Waves
    - 2.1 Extratropical (Planetary) Rossby Waves
    - 2.2 Extratropical Gravity Waves
    - 2.3 Equatorial Waves
    - 2.4 Thermal Tides
3. Wave–Mean Flow Interaction
    - 3.1 Transformed Eulerian Mean (TEM) Description
    - 3.2 Generalized Lagrangian Mean (GLM) Description
    - 3.3 Isentropic Coordinates
    - 3.4 "Downward Control" Principle
4. Stratospheric Sudden Warmings
    - 4.1 Phenomenological Description
    - 4.2 Theoretical Models
    - 4.3 The 2002 Vortex Split Event in the Southern Hemisphere
    - 4.4 Stratospheric Vacillations / Low–Order Models
5. Rossby Wave Breaking
    - 5.1 Stratospheric Surf Zone
    - 5.2 Shallow Water Modeling
    - 5.3 Contour Dynamics
    - 5.4 Poleward vs Equatorward Breaking
6. Large–Scale Mixing and Transport
    - 6.1 Chaotic Advection
    - 6.2 Equivalent Latitude, Equivalent Length, Effective Diffusivity
    - 6.3 Statistical Perspectives
    - 6.4 Age of Air