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FINAL TECHNICAL REPORT
FOR
NASA GRANT NGL 33-010-186

"Studies of Thermal Structures and Motions of Planetary Atmospheres"

Principal Investigator: Professor Peter J. Gierasch

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Principal Investigator: Professor Peter J. Gierasch
Center for Radiophysics
and Space Research
Cornell University

Peter J. Gierasch — 7 Nov. 90

Peter J. Gierasch — Date

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This grant supported theoretical work and data analysis on the dynamics and thermal structure of planetary atmospheres. Focus was on the neutral lower atmospheres of Mars, Jupiter, and Venus. The questions addressed were primarily related to observations by the Mariner 9 spacecraft to Mars, the Voyager mission to the outer planets, and the Pioneer Venus mission. The following publications presented the results of the work:

Blumsack, S. L., and P. J. Gierasch, 1973: The vertical thermal structure of the Martian atmosphere: Modification by motions. *Icarus 18*, 126-133.

Gierasch, P. J., A. P. Ingersoll, and R. T. Williams, 1973: Radiative instability of a cloudy planetary atmosphere. *Icarus 19*, 473-481.

Gierasch, P. J., 1973: Jupiter's cloud bands. *Icarus 19*, 482-494.

Gierasch, P. J., and O. B. Toon, 1973: Atmospheric pressure variation and the climate of Mars. *J. Atmos. Sci. 30*, 1502-1508.

Sagan, C., J. Veverka, P. Fox, R. Dubisch, R. French, P. J. Gierasch, L. Quam, J. Lederberg, E. Levinthal, R. Tucker, B. Eross, and J. B. Pollack, 1973: Variable features on Mars II. Mariner 9 global results. *J. Geophys. Res. 78*, 4163-4196.

Sagan, C., O. B. Toon, and P. J. Gierasch, 1973: Climatic change on Mars. *Science 181*, 1045-1049.

Gierasch, P. J., 1974: The differential rotation of the solar surface. *Ap. J. 190*, 199-210.

French, R. G., and P. J. Gierasch, 1974: Waves in the Jovian upper atmosphere. *J. Atmos. Sci. 31*, 1707-1712.

Goody, R. M., and P. J. Gierasch, 1974: The influence of vorticity upon free convection. *J. Atmos. Sci. 31*, 1021-1027.

Gierasch, P. J., 1974: Martian dust storms. *Rev. Geophys. and Space Phys. 12*, 730-734.

Gierasch, P. J., 1975: Meridional circulation and the maintenance of the Venus atmospheric rotation. *J. Atmos. Sci. 32*, 1038-1044.

Gierasch, P. J., 1975: Planetary atmospheres. *Rev. Geophys. and Space Phys. 13*, 790-793 and 863-871.

Gierasch, P. J., 1976: Jovian meteorology: Large-scale moist convection without a lower boundary. *Icarus 29*, 445-454.

French, R. G., and P. J. Gierasch, 1976: Diffraction calculation of occultation light curves in the presence of an isothermal atmosphere. *Astronomical J. 81*, 445-451.

Elliot, J. L., R. G. French, E. Dunham, P. J. Gierasch, J. Veverka, C. Church, and C. Sagan, 1977: Occultation of ϵ Geminorum by Mars. II. The structure and extinction of the Martian upper atmosphere. *Astrophys. J.* 217, 661.

Rossow, W. B., and P. J. Gierasch, 1977: The clouds of Venus. I. An approximate technique for treating the effects of coagulation, sedimentation and turbulent mixing of an aerosol. *J. Atmos. Sci. 34*, 405-416.

Elliot, J. L., R. G. French, E. Dunham, P. J. Gierasch, J. Veverka, C. Church, and C. Sagan, 1977: Occultation of ϵ Geminorum by Mars: Evidence for atmospheric tides? *Science 195*, 485-486.

French, R. G., P. J. Gierasch, and J. L. Elliot, 1978: Analysis of stellar occultation data: Effects of photon noise and initial conditions. *Icarus 33*, 186-202.

Houben, H., and P. J. Gierasch, 1977: Jupiter's tidal Q due to atmospheric tides. *Proc. Symp. on Planetary Atmospheres, Royal Society of Canada*, 79-83.

Flasar, F. M., and P. J. Gierasch, 1977: Eddy diffusivities within Jupiter. *Proc. Symp. on Planetary Atmospheres, Royal Society of Canada*, 85-87.

Gierasch, P. J., 1977: The Martian general circulation. *Proc. Symp. on Planetary Atmospheres, Royal Society of Canada*, 163-166.

Flasar, F. M., and P. J. Gierasch, 1978: Turbulent convection in rapidly rotating fluids. *Geophys. Astrophys. Fluid Dyn. 10*, 175-212.

Gierasch, P. J., A. P. Ingersoll, and D. Pollard, 1979: Baroclinic instabilities in Jupiter's zonal flow. *Icarus 40*, 205-212.

Marcus, Philip S., 1979: Stellar convection I. Modal equations in spheres and spherical shells. *Astrophys. J. 231*, 176-192.

Bogart, R. S., and P. J. Gierasch, 1979: Meridional circulation and the redistribution of heat in the solar convective envelope. *Ap. J. 228*, 624-629.

French, R. G., and P. J. Gierasch, 1979: The Martian polar vortex: Theory of seasonal variation and observations of eolian features. *J. Geophys. Res. 84*, 4634-4642.

Gierasch, P. J., P. Thomas, R. French, and J. Veverka, 1979: Spiral clouds on Mars: A new atmospheric phenomenon. *Geophys. Res. Letters 6*, 405-408.

Dunham, E., J. L. Elliot, and P. J. Gierasch, 1980: The upper atmosphere of Uranus: Mean temperature and temperature variations. *Ap. J. 235*, 274-284.

Marcus, Philip S., 1980: Stellar convection II. A multimode numerical solution for convection in spheres. *Astrophys. J. 239*, 622-639.

Marcus, Philip S., 1980: Stellar convection III. Convection at large Rayleigh numbers. *Astrophys. J. 240*, 203-217.

Bogart, R. S., P. J. Gierasch, and J. MacAuslan, 1980: Linear convective modes in the solar envelope. *Ap. J. 236*, 285-293.

Conrath, B. J., P. J. Gierasch, N. Nath, 1981: Stability of zonal flows on Jupiter. *Icarus 48*, 256-282.

Marcus, Philip S. Effects of truncation in modal representations of thermal convection. *J. Fluid Mech. 103*, 241-255.

Veverka, J., P. Gierasch, and P. Thomas, 1981: Wind streaks on Mars: Meteorological control of occurrence and mode of formation. *Icarus 45*, 154-166.

Pirraglia, J. A., B. J. Conrath, M. D. Allison, and P. G. Gierasch, 1981: Thermal structure and dynamics of Saturn and Jupiter. *Nature 292*, 677-679.

Flasar, F. M. B. J. Conrath, J. A. Pirraglia, P. C. Clark, R. G. French, P. J. Gierasch, 1981: Thermal structure and dynamics of the Jovian atmosphere. 1. The Great Red Spot. *J. Geophys. Res. 86*, 8759-8768.

Conrath, B., F. M. Flasar, J. A. Pirraglia, P. J. Gierasch, G. Hunt, 1981: Thermal structure and dynamics of the Jovian atmosphere. 2. Visible cloud features. *J. Geophys. Res. 86*, 8769-8776.

Kahn, R., and P. J. Gierasch, 1982: Long cloud observations on Mars and implications for boundary layer characteristics over slopes. *J. Geophys. Res. 87*, 867-880.

Magalhães, J., and P. J. Gierasch, 1982: A model of martian slope winds: Implications for eolian transport. *J. Geophys. Res. 87*, 9975-9984.

Gierasch, P. J., 1983: Dynamical consequences of ortho-hydrogen parahydrogen disequilibrium on Jupiter and Saturn. *Science 219*, 847-849.

Conrath, B. J., and P. J. Gierasch, 1983. Evidence for disequilibrium of ortho and para hydrogen on Jupiter from Voyager IRIS measurements. *Nature 306*, 571-572.

Conrath, B. J., and P. J. Gierasch, 1984: Global variation of the para hydrogen fraction in Jupiter's atmosphere and implications for dynamics on the outer planets. *Icarus 57*, 184-204 (1984).

Gierasch, P. J., and B. J. Conrath, 1985: Energy conversion processes in the outer planets. In *Recent Advances in Planetary Meteorology* (Garry E. Hunt, ed.), Cambridge U. Press, pp. 121-146.

Gierasch, P. J., 1985: On the energetics of the solar supergranulation. *Ap. J. 288*, 795-800.

Thomas, P., and P. J. Gierasch, 1985: Dust devils on Mars. *Science 230*, 175-177.

Jaquin, F., P. J. Gierasch, and R. Kahn, 1986: Limb hazes on Mars. *Icarus 68*, 442-461.

Conrath, B. J., and P. J. Gierasch, 1986: Retrieval of ammonia abundances and cloud opacities on Jupiter from Voyager IRIS spectra. *Icarus 67*, 444-455.

Gierasch, P. J., B. J. Conrath, and J. A. Magalhães, 1986: Zonal mean properties of Jupiter's upper troposphere from Voyager infrared observations. *Icarus 67*, 456-483.

Flasar, F. M., and P. J. Gierasch, 1986: Mesoscale waves as probes of Jupiter's deep atmosphere. *J. Atmos. Sci. 43*, 2683-2707.

Gierasch, P. J., 1987: Waves in the atmosphere of Venus. *Nature 328*, 510-512.

Gierasch, P. J., and B. J. Conrath, 1987: Vertical temperature gradients on Uranus: Implications for layered convection. *J. Geophys. Res. 92*, 15,019-15,029.

Flasar, F. M., B. J. Conrath, P. J. Gierasch, and J. A. Pirraglia, 1987: Voyager infrared observations of Uranus' atmosphere: Thermal structure and dynamics. *J. Geophys. Res. 92*, 15,011-15,018.

Taylor, F. W., P. J. Gierasch, P. L. Read, and R. Hide, 1988: The dynamics of planetary atmospheres. *Science Progress 72*, 421-450.

Gierasch, P. J., 1988: Clouds on the giant planets. *Nature 336*, 616.

Magalhães, J. A., A. L. Weir, B. J. Conrath, P. J. Gierasch, S. S. Leroy, 1988: Slowly moving thermal features on Jupiter. *Nature 337*, 444-446.

Conrath, B. J., P. J. Gierasch, and S. S. Leroy, 1990: Temperature and circulation in the stratospheres of the outer planets. *Icarus 83*, 255-281.

Gierasch, P. J., 1989: Hexagonal polar current on Saturn. *Nature 337*, 309.

Schinder, P. J., P. J. Gierasch, S. S. Leroy, and M. D. Smith (1990): Waves, advection and cloud patterns on Venus. *J. Atmos. Sci. 47*, 2037-2052.

Magalhães, J. A., A. L. Weir, B. J. Conrath, P. J. Gierasch, S. S. Leroy, 1990: Imaging and infrared observations of longitudinal structure on Jupiter. *Icarus*, in press.

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