Department of Physical and Chemical Science

Degree Profile of Master of Science in Physics

PROGRAM OF: Radiative transfer in atmosphere

Teacher: Prof. Giovanni Pitari ***CFU***: 3
Teacher: Prof. Vincenzo Rizi ***CFU***: 3

Solar radiation (G. Pitari)

Solar radiation in the terrestrial atmosphere. Top of atmosphere solar spectrum. Time variability of the top of atmosphere solar flux. Earth's surface solar spectrum. Radiation absorbing species in the clear sky atmosphere. Planetary albedo. Definition of optical parameters. Lambert-beer law for the direct solar flux. A simple radiative transfer model for the direct solar radiation. Use of sun photometers for radiation measurements at the earth's surface. Numerical examples.

Planetary radiation (V. Rizi)

Blackbody radiation. Planck's law for the energy density in blackbody radiation. Stefan-Boltzmann law. Blackbody radiation spectrum in the terrestrial atmosphere. Radiation absorbing species in the atmosphere: gas species, aerosols and clouds. Aerosol optical parameters as a function of wavelength.

Scattering processes in the terrestrial atmosphere (V. Rizi)

Scattering fundamentals (matter-radiation interaction): geometry, field of application, classification, nomenclature (i.e., cross section, phase function). Relevant parameters of scattering phenomena in the terrestrial atmosphere: atmospheric scatterers (particles) and refractive indices. Scattering regimes in atmosphere: Rayleigh (molecular) scattering, Mie scattering, optics. Theories and numerical examples. Optical phenomena: rainbows, glory, corona, reddening, blueing.

Multi-layer numerical models for the radiative transer (G. Pitari)

Plane-parallel and pseudo-spherical approximations. Delta Eddington approximation. Simplified models for radiative perturbation calculations. Numerical examples.

Applications for atmospheric observations (V. Rizi)

Lidar: basic principles and typical layouts; lidar systems for the observations of the vertical profiles of the aerosol optical properties, water vapour concentration, and clouds. Radar: basic principles, and meteorological radar systems for the observations of hydrometeors and precipitations. Passive photometry: basic principles, and the solar photometer (Cimel/AERONET) for the measurements of the aerosol optical depth and water vapor column.

Non-adiabatic heating rates (G. Pitari)

Definition of atmospheric heating rates. Simplified methods for the solar and planetary spectrum. Multi-layer model calculations including solar radiation scattering. Instantaneous and diurnally averaged values. Numerical examples.

Photolysis of gas species and simplified models for the ozone photochemistry (G. Pitari)

Definition of phododissociation coefficients for atmospheric gas species. Simplified methods for the direct solar radiation. Multi-layer model calculations including solar radiation scattering. Instantaneous and diurnally averaged values. Numerical examples. The Chapman cycle: photolysis of molecular oxygen and ozone. Ozone absorption bands. Photostationary state of tropospheric ozone: role for NO_2 photolysis. Numerical examples.

Reference text books:

1. Andrews, D.G., J.R. Holton, C.B. Leovy: Middle Atmosphere Dynamics, Academic Press, Orlando, FL, 1987.
2. Jacobson, M.Z.: Atmospheric pollution, Cambridge University Press, 2002.
3. Van de Hulst, H.C.: Light scattering by small particles, Dover publications, New York, NY, 1981.
4. Bohren, C.F., D.R. Huffman: Absorption and scattering of light by small particles, Wiley-Interscience publication, 1998.
5. Teachers-provided articles on scientific journals of the sector.

Exam: Tests during the course; final oral exam.