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Nota di contenuto	Cover; Contents; Preface; 1 Observation of clouds; 1.1 Water vapor in the atmosphere; 1.2 Where do clouds occur in the atmosphere?; 1.3 Conventional classifications of clouds; 1.3.1 High clouds (base height greater than 6000 m); 1.3.2 Middle clouds (base height between 2000 and 6000 m); 1.3.3 Low clouds (base height lower than 2000 m); 1.3.4 Clouds with vertical development; 1.4 Precipitation; 1.5 Observing clouds from an aircraft; 1.6 Cloud classification according to the phase of water substance; 1.7 Remote-sensing techniques of cloud observation; 1.7.1 Radar and lidar techniques 1.7.2 Satellite techniquesProblem; 2 The shape and size of cloud and precipitation particles; 2.1 Clouds as a colloidal system; 2.2 Frequency of liquid water and ice clouds in subfreezing environment; 2.3 Types of particles in clouds and precipitation; 2.4 Sampling of cloud and precipitation particles; 2.5 Cloud droplet size distributions; 2.5.1

Mathematical expressions of cloud drop size distributions; 2.6 Raindrop size distributions; 2.6.1 Double-gamma distribution; 2.7 Raindrop shape problem; 2.7.1 Quasi-spheroid approach; 2.7.2 Conical particle approach
2.8 Size and shape of graupel and hail2.9 Shape and size of ice crystals and snowflakes; 2.9.1 Habit of ice crystals; 2.9.2 Magono-Lee classification; 2.9.3 Dimensional relations; 2.9.4 Ice crystal and snowflake size and shape distribution; 2.9.5 Mathematical representations of ice and snow crystal shapes; Problems; 3 Molecular structures of water substance; 3.1 Single water molecule; 3.1.1 Electronic structure of the water molecule; 3.1.2 Electric dipole moment; 3.1.3 Water isotopes; 3.2 Hydrogen bonds; 3.3 Structure of water vapor; 3.4 Molecular structure of ice; 3.4.1 Ice-Ih Defects in ice-IhQuasi-liquid layer on ice surface; 3.4.2 Ice-Ic; 3.4.3 Other forms of ice; 3.5 Molecular structure of liquid water; Problems; 4 Bulk thermodynamic equilibrium among water vapor, liquid water, and ice; 4.1 Thermodynamic systems; 4.2 The first law of thermodynamics - conservation of energy; 4.3 Closed systems; 4.4 Adiabatic process for a closed system; 4.5 A simple conceptual model for small cumulus cloud formation; 4.6 Entropy; 4.7 Open systems; 4.8 Gibbs-Duhem relation; 4.9 General condition of thermodynamic equilibrium; 4.10 Clausius-Clapeyron equation
4.11 Phase diagram for water substance4.12 Supercooling and the Bergeron-Findeisen process; 4.13 Order of phase change; 4.14 Calculation of the saturation vapor pressures; Problems; 5 Surface thermodynamics of water substance; 5.1 The interface as a phase; 5.2 Surface tension of liquids; 5.3 Surface tension of solids; 5.4 Mechanical equilibrium among curved interface systems; 5.5 Contact angle and wettability; 5.6 Component chemical potentials in an ideal gas mixture; 5.7 The chemical potential of water in an aqueous solution; 5.8 Ideal and non-ideal solutions
5.9 Equilibrium between two phases separated by curved interface

Sommario/riassunto

This key new textbook provides a state-of-the-art view of the physics of cloud and precipitation formation, covering the most important topics in the field: the microphysics, thermodynamics and cloud-scale dynamics. Highlights include: the condensation process explained with new insights from chemical physics studies; the impact of the particle curvature (the Kelvin equation) and solute effect (the Kohler equation); homogeneous and heterogeneous nucleation from recent molecular dynamic simulations; and the hydrodynamics of falling hydrometeors and their impact on collision growth. 3D cloud-model simulations demonstrate the dynamics and microphysics of deep convective clouds and cirrus formation, and each chapter contains problems enabling students to review and implement their new learning. Packed with detailed mathematical derivations and cutting-edge stereographic illustrations, this is an ideal text for graduate and advanced undergraduate courses, and also serves as a reference for academic researchers and professionals working in atmospheric science, meteorology, climatology, remote sensing and environmental science.