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RAIZER, VICTOR Y., AND IGOR V. CHENY. 1998. **Passive microwave remote sensing of oceans.** Wiley-Praxis Series in Remote Sensing. viii + 195 p. \$95. ISBN 0-471-97170-7.

Microwaves are the least appreciated of the many kinds of radiation used to remotely sense the earth. This is probably because microwaves, which have wavelengths in the mm to cm range, are so far beyond the range of our senses. Human vision gives us access to the visible portion of the spectrum (0.4 to 0.8  $\mu\text{m}$ ); this range is extended by our thermal sensitivity, giving us an intuitive understanding of the spectrum between ultraviolet and thermal infrared. But we are totally insensitive to microwaves.

There are two forms of microwave remote sensing: active and passive. Active systems (radars) include real aperture radars (RARs) and synthetic aperture radars (SARs); they generate an electromagnetic pulse, transmit this towards the earth, and measure the reflected portion of the beam. Passive systems, usually referred to as radiometers, measure naturally emitted microwave energy. The temperature of an object determines the kind and amount of energy that it emits; at the temperature of the earth's surface (about 2,000 K) most emissions are in the thermal infrared and very little is in the microwave range. In consequence, aerial and orbital radiometer systems must have a coarse spatial resolution (pixels on the order of tens of kilometers) to collect a sufficiently large signal to background ratio. Radar systems, on the other hand, are capable of much finer spatial resolutions (pixels on the order of tens of meters) because they transmit their own microwave signal.

Based largely on research by Russian scientists that has been difficult to access up to now, this book presents the theory of how passive microwave energy interacts within the ocean-atmosphere system. The theory builds upon the governing Maxwell equations and is based on the thermodynamic and electrical characteristics of the air-water interface. Two model forms are considered: forward and inverse. Forward models make it possible to understand how a multitude of variables (physical, electrical, and thermodynamic) interact to give rise to an observed brightness temperature (the unit of measure of passive microwave radiometers); this book focuses principally on this type of model. In the second form of modeling (inverse) the magnitude and spectral dependence of the emission is measured and inverted to obtain a unique ensemble of conditions required to get the observation. Inverse modeling has evolved from the forward approach and is still in its infancy (interested readers are directed to a special issue of the *IEEE Transactions on Geoscience and Remote Sensing* 36(5) for further details).

Raizer and Cherny explain how the condition of the ocean surface (calm, breaking waves, foam, etc.) affects physical-electrical coupling, which determines microwave emission. For example, the calm ocean surface has a high dielectric constant relative to the air above; this gradient decreases when the surface is disturbed (e.g.,

by white caps) because microwave energy can penetrate the water-air mixture. The book's theoretical demonstration that a relationship between the fractal dimension of the wave field and the Beaufort wind force has application in the interpretation of orbital passive microwave data is particularly interesting.

The bulk of the book is dedicated to descriptions of experiments involving a combination of aircraft, ship-borne, and satellite-based studies. Phenomena detected with microwaves include internal waves, solitons, rain and relic rain events, frontal zones, and oceanic synoptic rings (Rossby Solitons). Explaining the physical linkages between these processes and the observed microwave signal is the book's strength. The authors present a further series of case studies for cyclone detection and trajectory analysis, thereby focusing on the ocean-atmosphere system rather than just the surface manifestation of atmospheric processes.

Various aerial and orbital passive microwave remote sensing systems are described, including details of the system that was used to produce the data in this book, and descriptions of how calibrated data were generated using hot and cold load approaches while in flight. The current workhorse for ocean-atmosphere process studies is the USA SSM/I system, which is aboard the American Defense Meteorological Satellite Program (DMSP). I was impressed with the overview of the operating frequencies, calibration, and archival locations of the SSM/I data streams and information on the two profiling systems which are operated in tandem with the SSM/I: the SSM/T1, which provides a vertical temperature profile of the atmosphere; and the SSM/T2 which provides an atmospheric water vapor profile. These profiling systems can be used in conjunction with the interpretation of the SSM/I data or as separate data sets when examining ocean-atmosphere processes. Also of interest is their description of the Meteor - 3M MTVZA satellite (scheduled to be launched in 1999), which will operate as a linearly polarized passive microwave system at 19, 22.2, 33, 36.5, 42, 48, and 91.6 GHz frequencies; this satellite has been specifically designed to maximize ocean-atmosphere process studies.

This book is the culmination of decades of Soviet/Russian investigations in the field of passive microwave radiometry of the ocean-atmosphere system. It is a good introduction to the theory of radiometry and presents several convincing examples of how microwaves can be used to study processes operating across the ocean-atmosphere interface. It will be a valuable reference for oceanographers interested in ocean-atmosphere exchanges.

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