Remote Sensing and Digital Image Processing

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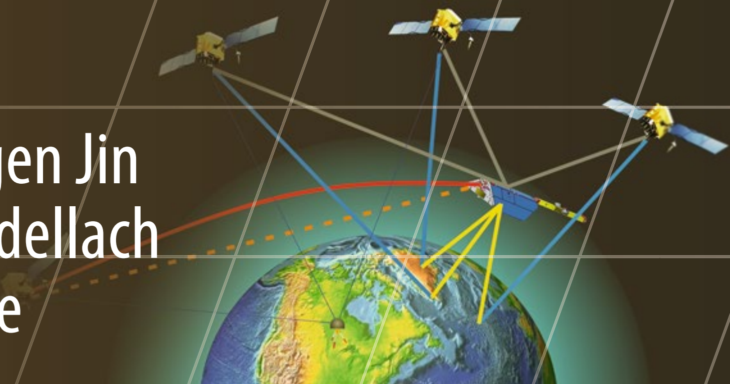

GNSS Remote Sensing

Theory, Methods and Applications

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Preface

The Global Navigation Satellite System (GNSS) has provided an unprecedented high accuracy, flexibility and tremendous contribution to navigation, positioning, timing and scientific questions related to precise positioning on Earth's surface, since Global Positioning System (GPS) became fully operational in 1994. Since GNSS is characterized as a highly precise, continuous, all-weather and near-real-time microwave (L-band) technique, additional more applications and potentials of GNSS are being explored by scientists and engineers. When the GNSS signal propagates through the Earth's atmosphere, it is delayed by the atmospheric refractivity. GNSS radio occultation together with ground GNSS have been used to produce accurate, all-weather, global refractive index, pressure, density profiles in the troposphere, temperature with up to the lower stratosphere (35–40 km), and the ionospheric total electron content (TEC) as well as electron density profiles, to improve weather analysis and forecasting, monitor climate change, and monitor ionospheric events. Therefore, GNSS has great potentials in atmospheric sounding, meteorology, climatology and space weather.

In addition, surface multi-path is one of main error sources for GNSS navigation and positioning. It has recently been recognized, however, that the special kind of GPS multi-path delay reflected from the Earth's surface, could be used to sense the Earth's surface environments. A recent interesting result on fluctuations in near surface soil moisture has been successfully retrieved from the ground GNSS multi-path, fairly matching soil moisture fluctuations in soil measured with conventional sensors. In addition, the space-borne GNSS received delay of the GNSS reflected signal with respect to the rough surface could provide information on the differential paths between direct and reflected signals. Together with information on the receiver antenna position and the medium, the delay measurements associated with the properties of the reflecting surface can be used to produce the surface roughness parameters and to determine surface characteristics. The Bistatic radar using L-band signals transmitted by GNSS can be as an ocean altimeter and scatterometer. A number of experiments and missions using GNSS reflected signals from the ocean and land surface have been tested and applied, such as determining ocean surface height, wind speed and wind direction of ocean surface, soil moisture, snow and ice thickness.

Therefore, the refracted, reflected and scattered GNSS signals can image the Earth's surface environments as a new, highly precise, continuous, all-weather and near-real-time remote sensing tool, which is expected to revolutionize various atmospheric sounding, ocean remote sensing and land/hydrology mapping, especially for various Earth's surfaces and the atmosphere. With the development of the next generation of multi-frequency and multi-system GNSS constellations, including the US's modernized GPS-IIF and planned GPS-III, Russia's restored GLONASS, and the coming European Union's GALILEO system and China's Beidou/COMPASS system as well as a number of Space Based Augmentation Systems, such as Japan's Quasi-Zenith Satellite System (QZSS) and India's Regional Navigation Satellite Systems (IRNSS), more applications and opportunities will be exploited and realized using new onboard GNSS receivers on future space-borne GNSS reflectometry and refractometry missions in the near future.

GNSS Remote Sensing –Theory, Methods and Applications has been written as a monograph and textbook that guides the reader through the theory and practice of GNSS remote sensing and applications in the atmosphere, oceans, land and hydrology. This book covers Chap. 1: Introduction to GNSS, Chap. 2: GNSS Atmospheric and Multipath Delays, Chap. 3: Ground GNSS Atmospheric Sensing, Chap. 4: Ground-Based GNSS Ionospheric Sounding, Chap. 5: Theory of GNSS Radio Occultation, Chap. 6: Atmospheric Sensing using GNSS RO, Chap. 7: Ionospheric Sounding using GNSS-RO, Chap. 8: Theory of GNSS Reflectometry, Chap. 9: Ocean Remote Sensing using GNSS-R, Chap. 10: Hydrology and Vegetation Remote Sensing, Chap. 11: Cryospheric Sensing using GNSS-R and Chap. 12: Summary and Future Chances. Chapters 1, 2, 3, 4, 7, 10, 11 and 12 were contributed from Prof. Shuanggen Jin, Chaps. 5 and 6 were contributed from Dr. Feiqin Xie, Chaps. 8 and 9 and part of Chap. 11 were contributed from Dr. Estel Cardellach as well as some contributions from Rui Jin and Xuerui Wu.

This book provides the theory, methods, and applications of GNSS Remote Sensing for scientists and users who have basic GNSS background and experiences. Furthermore, it is also useful for the increasing number of next generation multi-GNSS designers, engineers and users community. We would like to thank Assistant Editor's help and Springer-Verlag for their cordial collaboration and help during the process of publishing this book.

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