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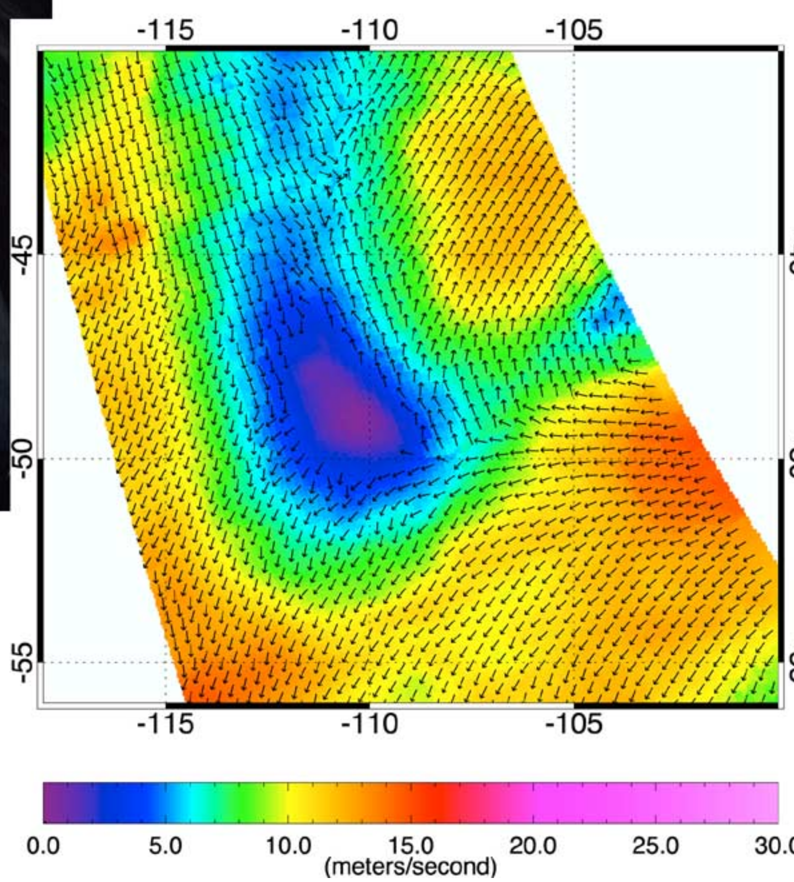
SPECIAL ISSUE ON THE WINDSAT SPACEBORNE POLARIMETRIC RADIOMETER



WindSat fully polarimetric radiometer prior to spacecraft integration, and its retrieved wind vector field on September 12, 2003 in the South Pacific.

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SPECIAL ISSUE ON THE WINDSAT SPACEBORNE POLARIMETRIC RADIOMETER—CALIBRATION/VALIDATION AND WIND VECTOR RETRIEVAL

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About the Cover: WindSat, the first fully polarimetric spaceborne microwave radiometer, was designed, built, and tested at the Naval Research Laboratory in Washington, DC. Its primary objective is to test and evaluate the viability of using passive polarimetric radiometry to retrieve the ocean surface wind vector. The example retrieved windfield shown on the cover shows an area of the South Pacific on September 12, 2003. Wind speed is indicated by the color. The wind direction is based on the selected ambiguity using median filtering with nudging. For more information, see "A Nonlinear Optimization Algorithm for WindSat Wind Vector Retrievals," by Bettenhausen *et al.*, which begins on page 597. WindSat photo by M. Savell.

Foreword to the Special Issue on the WindSat Spaceborne Polarimetric Radiometer—Calibration/Validation and Wind Vector Retrieval

With the launch of the WindSat instrument on the Coriolis spacecraft on January 6, 2003, a new era in microwave radiometry began. WindSat is the first fully polarimetric spaceborne microwave radiometer. Its objective is to measure the partially polarized emission from the ocean surface and, therefore, test and fully evaluate the viability of using passive polarimetric radiometry to retrieve the ocean surface wind vector. The WindSat payload was designed, built, and tested at the Naval Research Laboratory (NRL) in Washington, DC, under sponsorship from the U.S. Navy and the National Polar-orbiting Operational Environmental Satellite System (NPOESS). Winds over the ocean affect nearly every aspect of naval operations including ship routing, carrier operations, and search and rescue. The global ocean surface wind vector (speed and direction) provides essential information for short-term weather forecasts and warnings, nowcasting, and climatology and oceanography studies in both the civilian and military sector. NPOESS is required to provide ocean surface wind vectors operationally and has opted to fulfill this requirement with a polarimetric radiometer called the Conically-scanned Microwave Imager and Sounder (CMIS). CMIS will add global ocean surface wind direction to the many other environmental parameters already retrieved using microwave radiometry. In addition to supplying wind information to the Navy, WindSat also provides significant risk reduction for CMIS with regard to instrument design, retrieval algorithm development, and on-orbit calibration and validation.

This special issue publishes 18 papers representing some of the earliest scientific and technical research results using WindSat data products. The papers span three principle areas: sensor calibration; forward modeling and wind retrievals; and WindSat applications and product evaluation. The diversity of the papers and the authors indicates the importance and widespread interest in the WindSat program.

Of the 18 papers, eight address sensor calibration. We see innovative techniques such as deep-space viewing and vicarious calibration used to evaluate the quality of the WindSat brightness temperature data. Two papers discuss the geolocation and pointing of WindSat. These issues are important for any radiometer, but even more so for a polarimetric radiometer. The pointing knowledge is especially critical because of the cross-polarization that can be induced by unaccounted errors in the sensor pointing and alignment. A growing problem for microwave radiometry is radio-frequency interference (RFI), which continues to spread and contaminate passive microwave data. The papers discuss identification and impact of RFI on WindSat. The final calibration paper addresses the WindSat warm-load calibration, which experienced anomalies due to unexpected thermal gradients. This is an important topic as algorithms require higher accuracy brightness temperature data. Furthermore, the WindSat warm-load anomaly is an excellent example of risk reduction for CMIS, which has redesigned its warm load as a direct result of this WindSat investigation.

The modeling and retrieval group contains papers describing empirical forward models, models built on earlier aircraft-based results, and physical forward models tuned to WindSat data. Because of the computational requirements of physical forward models, we have a paper describing an efficient implementation of such a model, thus making it viable for near real-time data processing. To more completely break down the components contributing to the ocean surface emissivity, experimental results quantifying the contribution of foam are presented. Two of the retrievals described in this section apply maximum-likelihood estimation (MLE), which is a heritage approach commonly used in scatterometer wind vector processing. The approaches differ in that one operates directly on the brightness temperatures, while the other estimates wind vector from the surface emissivity, which is derived from the brightness temperature by decomposition of the radiative transfer equation. An alternative retrieval method to the MLE approach uses optimal estimation to simultaneously retrieve the wind vector and other ocean environmental parameters.

The success of the WindSat demonstration lies in the evaluation and application of WindSat products to real-world problems. The wind products derived from WindSat are compared with heritage sources of ocean winds such as QuikSCAT, buoys, and numerical weather models. Wind vector error models for WindSat and QuikSCAT are developed to more generally evaluate the performance of these two sensors. Tropical cyclone tracking, analysis, and prediction are critical applications of satellite data such as that from WindSat. Two papers study WindSat measurements in and around tropical cyclones. Their results suggest the great promise of polarimetric radiometetry for severe weather conditions, in spite of the fact that these early wind vector results were primarily developed for more common conditions of wind speeds below 15 m/s. The final evaluation paper examines the potential impact of polarimetric microwave radiometer on numerical weather prediction.

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Numerical weather prediction centers around the world will be some of the largest users of WindSat and CMIS data, making use of both direct radiances and derived environmental products to produce global meteorological analyses and forecasts.

We believe that this collection of papers demonstrates the success of the WindSat project and points to a promising future for polarimetric microwave radiometry. Work continues to improve upon the results presented here, and additional applications over land, ice, and ocean are being developed. Furthermore, the results from WindSat are being applied to CMIS to ensure that it succeeds in providing ocean surface wind vectors in near real time to the operational community of the next generation.

We would like to thank the authors in this special issue for their high-quality work and enthusiastic response. Of course, this issue would not have been possible without the generous contributions of the reviewers, who provided thorough reviews in a timely manner. We are grateful to the IEEE Geoscience and Remote Sensing Society for providing us with a venue to present these early WindSat results, and to Prof. Jon Benediktsson for shepherding us through the logistics of preparing this special issue.

PETER W. GAISER, *Guest Editor*
Naval Research Laboratory
Washington, DC, 20375

CHRISTOPHER S. RUF, *Guest Editor*
University of Michigan
Department of Atmospheric, Oceanic, and Space Sciences
Ann Arbor, MI 48109

Peter W. Gaiser (S'91–M'93–SM'04) received the B.S. degree in electrical engineering from Virginia Polytechnic Institute and State University, Blacksburg, in 1987, and the Ph.D. degree from the University of Massachusetts, Amherst, in 1993, where he studied microwave remote sensing, with emphasis on synthetic aperture interferometric radiometry.

He has been with the Naval Research Laboratory (NRL), Washington, DC, since 1993, and currently Acting Head of the Remote Sensing Physics Branch, Remote Sensing Division at NRL. While at NRL, he has been involved in polarimetric radiometry research. His research interests also include instrument design, data collection, and model development specifically for the purpose of ocean wind vector measurements from space. He is the Principal Investigator for the WindSat spaceborne polarimetric microwave radiometer demonstration project.

Christopher S. Ruf (S'85–M'87–SM'92–F'01) received the B.A. degree in physics from Reed College, Portland, OR, and the Ph.D. degree in electrical and computer engineering from the University of Massachusetts, Amherst.

He is currently a Professor of atmospheric, oceanic, and space sciences and electrical engineering and computer science at the University of Michigan, Ann Arbor. He has worked previously as a Production Engineer for Intel Corporation, Santa Clara, CA, as a member of the technical staff for the Jet Propulsion Laboratory, Pasadena, CA, and as a member of the faculty at Pennsylvania State University, University Park. During 2000, he was a Guest Professor at the Technical University of Denmark, Lyngby. His research interests involve microwave remote sensing instrumentation and geophysical retrieval algorithms. He is currently involved with spaceborne radiometers on the current TOPEX, GeoSat Follow-on, Jason, and WindSat and the upcoming CMIS, Aquarius, and Juno missions. He has published over 87 refereed articles and is a past Associate Editor and Guest Editor for *Radio Science*.

Dr. Ruf has received three NASA Certificates of Recognition and four NASA Group Achievement Awards, as well as the 1997 GRS-S Transactions Prize Paper Award and the 1999 IEEE Judith A. Resnik Technical Field Award. He is a past Editor of the IEEE GRS-S Newsletter and currently an Associate Editor and Guest Editor of the IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING. He is a member of the AGU, AMS, and URSI Commission F.