Section 4   Radio Astronomy

Chapter 1   Radio Astronomy

Chapter 1. Radio Astronomy

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1.1 Algorithms for Operational Meteorological Satellite Instruments

Sponsor

MIT Lincoln Laboratory
    Agreement BX-6178

Project Staff

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This project provides scientific support to the National Oceanic and Atmospheric Administration (NOAA) for the advanced microwave sounding units A and B (AMSU-A, AMSU-B), which are scheduled for launch on NOAA polar-orbiting weather satellites starting in 1997, and also for improved instruments. The effort emphasizes development of atmospheric transmittance algorithms, estimation of surface emissivity and precipitation, issues related to instrument design and specification, and general retrieval methods.

1.2 Development and Operation of an NPOESS Aircraft Sounder Testbed Passive Microwave Sensor

Sponsor

MIT Lincoln Laboratory
    Agreement BX-6433

Project Staff

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The NPOESS Aircraft Sounder Testbed (NAST) is a cooperative effort by MIT Lincoln Laboratory, RLE, and the University of Wisconsin. An infrared interferometer sounder and a co-located microwave sounder will be flown on the NASA ER-2 aircraft for the purpose of answering technical questions related to the National Polar-orbiting Operational Environmental Satellite System (NPOESS). The microwave sounder will be an improved version of the microwave temperature sounder (MTS) which has been flown previously by RLE. The new MTS will have eight channels between 50 and 56 GHz and nine channels near 119 GHz. It will be fully scanning and will have a three-point calibration system (two blackbody targets and a zenith view) for accurate calibration.

1.3 Earth Observing System: Advanced Microwave Sounding Unit

Sponsor

National Aeronautics and Space Administration/
    Goddard Space Flight Center
    Grant NAS5-31376

Project Staff

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The AMSU will provide microwave-band measurements to the atmospheric infrared sounder (AIRS), which will be a facility instrument on NASA's planned Earth observing system (EOS). This effort is directed toward developing algorithms for the retrieval of temperature and humidity profiles, precipitation, sea ice, land snow cover, and other parameters. The temperature and humidity profiles

obtained from AMSU are intended to provide initial conditions for the AIRS infrared cloud-correction and profile retrieval algorithms.

Data from present satellite instruments with lower spatial resolution were used to test the microwave algorithms. The humidity retrievals show spatial patterns that are sufficiently distinct at different altitudes to demonstrate vertical resolution, although a quantitative measure of vertical resolution has not been defined.

Methods of combining AIRS and AMSU measurements in an optimum cloud-clearing algorithm were studied. Our approach is to estimate the impact of clouds on the temperature retrieval at each of nine AIRS locations associated with one AMSU-A location. Then, this information is then input to a neural network that estimates the temperature profile as a nonlinearly weighted average over the nine locations.

An information-conserving data compression method was developed for application to high-data-rate atmospheric sounders. It compresses the geophysical component of the data in a non-deleterious way by noise-adjusted principal components analysis and codes losslessly any instrument channels exhibiting anomalies greater than three standard deviations above the noise level. This method, described as semi-lossless, has the robustness of lossless coding, but can approach the high-compression performance of lossy coding.

1.3.1 Publications

Blackwell, W.J., and D.H. Staelin. *"Simulation Analyses of the Integrated Multispectral Atmospheric Sounder (IMAS) for Tropospheric Sounding of Temperature and Water Vapor Profiles."* Paper presented at the Fifth Specialist Meeting on Microwave Radiometry and Remote Sensing of the Environment, Boston, Massachusetts, November 4-6, 1996.

Rosenkranz, P.W. *"Retrieval of Atmospheric Moisture Profiles from SSM/T2 Measurements."* Paper presented at the Fifth Specialist Meeting on Microwave Radiometry and Remote Sensing of the Environment, Boston, Massachusetts, November 4-6, 1996.

Schwartz, M.J., P.W. Rosenkranz, and D.H. Staelin, "Atmospheric Transmittance Measurements Near 118-GHz." *Proceedings of the SPIE Conference GOES-8 and Beyond,* Denver, Colorado, August 7-9, 1996.

1.4 Geostationary Microwave Sounder Study

Sponsor

MIT Lincoln Laboratory
    Agreement CX-19383

Project Staff

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This project provides supporting studies of candidate sounder designs to the Geosynchronous Microwave Sounder Working Group (GMSWG), which is composed of government and university personnel. GMSWG was formed at the order of NOAA for the purpose of identifying requirements, determining technology readiness, and making recommendations for a microwave sounder to be added to the Geostationary Operational Environmental Satellite (GOES) program.

GMSWG, chaired by Professor Staelin, has developed a reference sounder design that envisions a 2 m-diameter antenna and four frequency bands, which include the oxygen lines at 119 and 425 GHz and the water lines at 183 and 380 GHz. Simulations of temperature and humidity retrievals from this instrument predict accuracies comparable to low-earth-orbit sounders, except that the 425 and 380 GHz bands are limited by continuum water-vapor absorption to parts of the atmosphere with water-vapor overburden less than 0.3-0.6 kg/m². The 119 and 183 GHz bands, in contrast, allow sounding down to the surface. Subsatellite horizontal spatial resolution would be ~20 km for the 380-425 GHz bands, however, compared with ~66 km at 119 GHz.

1.5 High-Resolution Passive Microwave Imaging of Atmospheric Structure

Sponsor

National Aeronautics and Space Administration/
    Goddard Space Flight Center
    Grant NAG5-10

Project Staff

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A zenith-scanning airborne imaging spectrometer, the Microwave Temperature Sounder (MTS), incorporating eight double-sideband channels centered on the 118.75-GHz oxygen resonance, was employed to measure atmospheric transmittance to space. The MTS channels have nominal single-sideband widths of 270 MHz and center frequencies of 470-1880 MHz from the line center. Observations were obtained continuously as a NASA ER-2 aircraft ascended to ~20 km altitude and descended on four flights. Nearby radiosondes and navigational and air temperature data from the aircraft permit comparison of the radiometric measurements with predictions of microwave transmittance models. The views of atmospheric radiance against the cosmic background provide sensitivity to conditions in the troposphere including the tropopause region. Modeled and retrieved atmospheric opacities presently agree to within the accuracy of the measurements, which is typically ~5 percent through altitudes from 5 to 15 km. Analysis of data from an associated switched-frequency radiometer operating 52-54 GHz as part of MTS is also being analyzed. Work began on designing improvements to the ER-2 aircraft instrument which will address issues of calibration accuracy, frequency coverage, and the ability to scan laterally to produce images in the 50-57 GHz region.

1.6 Reduction of Variation

Sponsor

MIT Leaders for Manufacturing Program

Project Staff

Professor David H. Staelin, Ron Cao, Junehee Lee

Reduction of process and product variation is a primary goal in most manufacturing operations. Progress this year has centered on data mining of data-rich web manufacturing processes. Two very different web processes are being analyzed. In each case, hundreds or thousands of parameters are being monitored continuously. Generic methods are being developed for characterizing modes of behavior of complex nonlinear processes and identifying anomalies.