Remote Sensing and Estimation

Academic and Research staff
Professor David H. Staelin, Dr. Philip W. Rosenkranz

Graduate Students
William J. Blackwell, Chuck Choongyeun Cho, Frederick W. Chen, R. Vincent Leslie, Jessica A. Loparo, Amy V. Mueller, Andrew Sanchez

Technical Support
John W. Barrett, Scott C. Bressler, Seth M. Hall

1. NPOESS Aircraft Sounder Testbed (NAST) Passive Microwave Sensor

Sponsor
MIT Lincoln Laboratory, Agreement BX-7601
National Oceanic and Atmospheric Administration Contract DG133E-02-CN-0011

Project Staff
Professor David H. Staelin, Dr. Philip W. Rosenkranz, William J. Blackwell, R. Vincent Leslie, Jessica A. Loparo, Andrew Sanchez

The NPOESS Aircraft Sounder Testbed (NAST) is composed of two instruments, one of which is a ~28-channel microwave sounder (NAST-M) built and operated by the RLE Remote Sensing and Estimation Group. NAST flies together with other instruments on high altitude aircraft like the NASA Proteus and ER-2 to explore technical issues related to the National Polar-Orbiting Operational Environmental Satellite System (NPOESS). This year two new radiometer subsystems were added with passbands near the water-vapor line at 183 GHz and the oxygen line at 425 GHz. These are being operated along with the previously existing 50-56 GHz and 119 GHz subsystems, both at oxygen resonances [1]. The 183-GHz spectrometer can be used to retrieve moisture profiles below the aircraft, while the others provide temperature profiles; all of them provide images of precipitation cells, which have different signatures at the different frequencies.

During 2002 we participated in the IHOP field experiment in Oklahoma and the CRYSTAL-FACE experiment in Florida. These were multi-aircraft and multi-observer team missions for the purpose of measuring atmospheric moisture and clouds in various meteorological situations. The new radiometer subsystems yielded unique data on the utility of these frequencies for remote sounding, and their response to clouds and both convective and stratiform precipitation.

Conference Papers Presented

1. Blackwell, W.J. and D.H. Staelin, “Analysis of cloud impact on infrared and microwave atmospheric sounding performance using NAST,” *IEEE International Geoscience and Remote Sensing Symposium,* Toronto, Canada, Vol. 1, pp 562-564, June 24-28, 2002.

2. Earth Observing System: Advanced Microwave Sounding Unit

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

Project Staff
Professor David H. Staelin, Dr. Philip W. Rosenkranz, William J. Blackwell, Chuck Choongyeun Cho, Frederick W. Chen

The Aqua satellite of NASA's Earth Observing System was launched May 4, 2002. Its instrument complement includes AIRS, AMSU-A, and HSB, which are treated as a single facility for the purpose of retrieving profiles of atmospheric parameters such as temperature and moisture. We have supplied algorithms for the purpose of retrieving precipitation, cloud liquid water content, microwave surface emissivity, and first-guess profiles of temperature and water vapor from the microwave channels [1]. The latter two profiles are used to initialize the cloud-clearing of infrared channels, and also constitute the product in overcast fields of view.

Significant improvements were made this year in the accuracy of cloud liquid water retrievals, and a higher spatial resolution (15-km) version of the precipitation retrieval algorithm was developed [2-4]. Methods of correcting the infrared channels for clouds were also investigated. Intense Arctic snowstorms have been noted in the Aqua data, an atmospheric phenomenon difficult to observe with other means. Microwave brightness temperature observations from Aqua were compared with calculations based on radiosondes launched underneath the satellite, and satisfactory agreement with radiative transfer theory has been obtained, considering that corrections for sidelobes of the antennas are not yet in place.

Journal Articles, Accepted for Publication

1. P. W. Rosenkranz, 'Rapid radiative transfer model for AMSU/HSB channels,' *IEEE Trans. Geoscience and Remote Sensing, 41,* 2, February, 2003.

2. Chen, F. W., and D. H. Staelin, "AIRS/AMSU/HSB Precipitation Estimates," *IEEE Trans. on Geoscience and Remote Sensing, 41,* 2, February, 2003.

Conference Papers Presented

Chen, F.W. and D.H. Staelin, "Precipitation-rate retrievals at 15- and 50-km resolution using AMSU passive microwave data," *2002 National Radio Science Meeting*, Boulder, Colorado, January 9-12, 2002.

Chen, F.W. and D.H. Staelin, "Global millimeter-wave observations of precipitation using AMSU on the NOAA-15 satellite," *IEEE International Geoscience and Remote Sensing Symposium*, Toronto, Canada, Vol. 1, pp 460-462, June 24-28, 2002.

3. Passive Microwave Spectral Imaging of Atmospheric Structure

Sponsor
National Aeronautics and Space Administration/Goddard Space Flight Center
Contract NAG5-11390

Project Staff
Professor David H. Staelin, Dr. Philip W. Rosenkranz,

A very efficient algorithm was developed for integrating the equation of radiative transfer in a planar-stratified atmosphere with multiple scattering [1]. The algorithm uses an ensemble of trial functions that are constructed so as to satisfy the boundary conditions at the top of the atmosphere; boundary conditions at the bottom are then imposed after integration.

Possible passive microwave instrument configurations for use in geostationary orbit were also analyzed [2-3]. The ability of such systems to monitor precipitation, hurricane cores, and other rapidly evolving phenomena is unique, and would fill an important gap in our ability to monitor global weather phenomena.

Journal Articles, Published

P. W. Rosenkranz, 'Radiative transfer solution using initial values in a scattering and absorbing atmosphere with surface reflection', *IEEE Trans. Geoscience and Remote Sensing, 40*, 1889-1892 (2002).

Conference Papers Presented

Gasiewski, A.J., D.H. Staelin, and B. Bizzarri, “The Geosynchronous Microwave Sounder Imager,” *Twelfth International TOVS Study Conference*, Lorne, Australia, February 27-March 5, 2002.

Bizzarri, B., A.J. Gasiewski, and D.H. Staelin, “Initiative for MW/mm sounding from geostationary orbit,” *IEEE International Geoscience and Remote Sensing Symposium*, Toronto, Canada, *Vol. 1*, pp 548-552, June 24-28, 2002.

4. Blind Multivariate Source Separation

Sponsor:
MIT Lincon Laboratory
Contract BX-8463

Staff:
Professor David H. Staelin, Amy V. Mueller

New approaches to the blind identification and characterization of multivariate events in noisy data fields are being developed in collaboration with Keith M. Forsythe and Daniel Bliss at Lincoln Laboratory. This year an algorithm for Order, Noise, and A (ONA) estimation was developed for the case where the order k of the signal space is unknown. It is an extension of a similar algorithm for Iterated Order Noise (ION) estimation developed by Lee and Staelin [1].

Only m observed vectors x of dimension n > ~3k are given, where x = **A**p + **G**w. ONA iteratively estimates the signal order k using a scree plot and then the values of **A**p, **G**, and w using the Expectation-Maximization (EM) algorithm, where w is a white noise vector with unity variance and **G** is diagonal. After convergence the final step estimates **A** and the set of p vectors using the Second-Order Blind (SOBI) algorithm, where p has k elements each with unity variance. One set of experiments with nominal values for n, k, and m of 120, 24, and 2400 yielded SNR's for **A**p, **A**, p, **G**w, **G**, w, and k of ~28, 2.4, -2.0, 12, 34, 8, and 13 dB, respectively, when the average SNR for **A**p versus **G**w was 16 dB and all unknowns were Gaussian. The SNR for the estimated p increased to 2-3.5 dB when k was reduced to 3-4 and the SNR for Ap versus **G**w increased to 60 dB. For a large set of non-Gaussian factory data, ONA identified significantly more groups of physically related variables than did principal component analysis (PCA).

References

[1] Lee, J. and D.H. Staelin, "Iterative signal-order and noise estimation for multivariate data," *Electronics Letters*, **37**(2), pp. 134-135, 2001.