CAMEX-4 Progress Report- April 2002

Deriving Microphysical Cloud Profiles using Airborne Active and Wideband Passive Microwave Observations

PI: Gail Skofronick Jackson
(GSFC/UMBC/GEST, Code 975, 301-614-5720, gailsjackson@ieee.org)
Co-I: Dr. James A. Weinman

Research Accomplishments

A physically-based iterative retrieval algorithm was designed to estimate microphysical cloud hydrometeor profiles using microwave observations from the ER-2 aircraft obtained during CAMEX-3. The algorithm uses one active radar channel and up to 27 passive channels spanning 10 to 340 GHz. Differences between the calculations (using the iteratively estimated hydrometeor profile) and the observations drive the iterative retrieval algorithm. Realistic foam-covered ocean surfaces were assumed, where the wind speeds tapered as a function of the distance from the hurricane eye. The estimated profiles provide content and drop size distribution details for cloud water, rain, and frozen hydrometeors from 0 to 18 km in 0.5 km increments. The retrieved profiles are two-dimensional in that they span a nadir segment of the ER-2 flight line and thus can follow the changes in the hydrometeor profiles as the aircraft passes over various stages of the storm (e.g., convective to anvil). The advantage of the algorithm is the focus on high frequency (>90 GHz) brightness temperatures that provide significant detail about the upper altitude frozen hydrometeor characteristics. Microphysical profiles of anvil, convective and quasi-stratiform cloud regions associated with Hurricane Bonnie using the CAMEX-3 data were estimated and favorably validated against in-situ and indirect observations.

One major accomplishment in the past year was improving the microphysical profile retrieval algorithm. Improvements included increasing the number of channels used in the retrieval algorithm, advancing the performance of the retrieval hydrometeor size distribution adjustment algorithm, and refining the retrieved profile resolution.

A second accomplishment was the validation of the retrieved cloud profiles. The qualitative validation using coincident CAMEX-3 observations showed that the retrieved particle size distributions are well corroborated by these independent in situ measurements from a DC-8 aircraft flying at a 12 km altitude. In addition, brightness temperature calculations at frequencies corresponding to observed channels reserved for validation purposes (near 50-60 GHz and 118 GHz) are within the convergence criteria of the retrieval algorithm. A journal paper was submitted to the *Journal of Applied Meteorology* in January 2002 to describe the above work.

A third area of research involved determining the sensitivity of wideband calculated brightness temperatures to differing cloud and hydrometeor parameterizations. In this work, six different parameterizations (e.g., dry snow and graupel versus wet snow and graupel) were used to compute brightness temperatures for 12 frequencies between 6 and 410 GHz. The results show that brightness temperatures can vary by up to 100 Kelvin. When the calculations were compared to minimum and maximum values of observations from CAMEX-3, all but two parameterizations fell within the minimum and maximum observed values. A journal paper was published to report the findings of this research [Skofronick-Jackson, et al. 2002].

Current Research Objectives

The research goals focus on (1) transferring the CAMEX-3 based retrieval algorithm for use with the more recent (2001) CAMEX-4 data, (2) identifying CAMEX-4 priority cases and performing retrievals, and (3) developing and validating dielectric mixing theories appropriate for high frequencies and incorporating them into the retrieval so that fluffy snow and partially melted drops can be included. For the first goal, the retrieval algorithm has been modified (but not yet tested) for use with the CAMEX-4 modified channel set (the MIR 220 and 340 GHz channels have been removed from the retrieval analysis and selected channels from the HAMSR instrument included). Secondly, priority cases will be limited to (a) those when the AMPR, EDOP, and HAMSR were all functioning properly, (b) those with well-coordinated DC-8 and ground instrument observations for validation, and (c) those of interest to multiple CAMEX-4 PI. Retrievals will commence when calibrated data is released and the multiple instrument data sets have been properly aligned and coordinated. With respect to including fluffy and partially melted snow in the retrievals, dielectric mixing models are being tested in the laboratory and theoretically for high frequencies. (At high frequencies, dielectric mixing models are theoretically invalid due to the size of the inclusions with respect to the wavelength.)

Specific Accomplishments

- Estimated and validated two-dimensional microphysical profiles for anvil, convective, and quasi-stratiform regions of Hurricane Bonnie using CAMEX-3 using AMPR, MIR, and EDOP observations.
- Investigated the sensitivity of brightness temperatures (6 to 410 GHz) to variations in the drop size distribution and ice-air-water ratios of the frozen particles.
- Examined the ice microphysics for various storm regions.
- The radiative transfer models were examined and tested for validity for these frequencies and hydrometeor characteristics.
- Research results were submitted as a NASA Goddard Code 970 Science Highlights slide.
- Journal paper submitted to *J. Applied Meteorology*.

Recent Refereed Publications

1. G. M. Skofronick-Jackson, A. J. Gasiewski, and J.R. Wang, "Influence of Microphysical Cloud Parameterizations on Microwave Brightness Temperatures," *IEEE Trans. Geosci. and Remote Sensing*, vol. 40, pp. 187-196, 2002.
2. G. M. Skofronick-Jackson, J. R. Wang, and J. A. Weinman, "Iterative 2D Hydrometeor Profile Retrievals using Radar and Wideband Radiometer Observations," *Proceedings of the IGARSS*, Sydney, Australia, pp. 664-666, July 9-13, 2001.
3. G. M. Skofronick-Jackson, J.R. Wang, G.M. Heymsfield, R. Hood, W. Manning, R. Meneghini, and J.A. Weinman, "Combined Radiometer-Radar Microphysical Profile Estimations with Emphasis on High Frequency Brightness Temperature Observations," submitted to *J. of Applied Meteorology*, January 2002.