N93-20069

Global Rainfall Monitoring by SSM/I

E.C. Barrett, C. Kidd and D. Kniveton

Background of the Investigation

Rainfall is a key environmental parameter for which *in situ* observational data has always been generally inadequate. Today, the need for rainfall data is even greater than before, not least because of growing concerns for global weather and climate change, improved evaluations of the global hydrological cycle, and the significance of rainfall for water supplies, crop growth, industry and commerce. Since the 1970s many techniques have been tested for improved rainfall monitoring using satellite visible and/or infrared data in support of ground observations. However, problems exist with all such methods because the radiances measured by the satellite emanate almost exclusively from the tops of clouds. Passive microwave data afford fresh hope for more physically direct monitoring of rainfall by satellites, especially for climate time scales.

The WetNet Project, "a pilot programme...designed to enhance scientific analysis and encourage an interdisciplinary approach to research problems" is based on the DMSP-SSM/I sensor, and therefore holds particular promise for rainfall monitoring. The activity described in this Report is part of the WetNet effort, which embraces a total of 42 laboratories, 7 outside the USA. A key element of WetNet is ..."cooperative research among teams of scientists..."; the WetNet Precipitation Working Group is the biggest of its teams. Since early 1991 E.C.Barrett has served (at NASA's request) as WetNet PrecipWG Chairman. In this capacity he has organised a global algorithm precipitation intercomparison project (PIP-1) as outlined below.

Significant Accomplishments in the last year

During 1991, three main activities were undertaken:

1. Development and testing of a preliminary global rainfall algorithm, based on frequency differencing over land and polarization differencing over coasts and oceans. Initial results (including both global maps and mean latitudinal profiles of estimated rainfall) have been compared qualitatively with climatology, and areas of difficulty identified. The latter include areas of strong surface

scattering, most notably sand and snow.

2. Researching areas of strong surface scattering in attempts to reduce or even remove related global rainfall algorithm ambiguities. Results for selected desert areas (Sahara, Great Australian Desert) confirm that use of horizontally-polarized brightness temperatures in such areas instead of the more generally approved vertically-polarized data largely eliminate the sand/rainfall ambiguity problem. Meanwhile, studies in selected snow-covered areas (Great Britain) confirm that rain/snow ambiguities are likely to be more difficult to resolve, although evaluations of diurnal temperature variations of snow surfaces may be helpful in some situations. Global tests have begun with a modified global rainfall algorithm incorporating the above findings, and the results from possibly the first such algorithm to eschew a sand mask are encouraging.

3. Formulation of a program of work for the WetNet PrecipWG, primarily the Precipitation Intercomparison Project, PIP-1, to be undertaken during 1992. Recognising that present SSM/I rainfall algorithms are not yet mature, but increasing calls are being made for such algorithms to be implemented operationally, PIP-1 was proposed by E.C.Barrett.

   (a) to facilitate intercomparison of existing algorithms (including SSM/I, GPCP infrared, Spencer MSU, and ECMWF forecast model outputs) and through requested results conforming to a careful set of specifications for a chosen period of time (August through November 1987, for which data from all seven SSM/I channels were available);

   (b) to permit validation of these results through reference to selected surface data sets (GPCC continental raingauge, and Morrisey's Pacific atoll, data sets);

   (c) to enable elucidation of the physical reasons for differing results from different algorithms; and

   (d) to move towards the development of a "community algorithm" for optimum performance on a global scale.

A sub-committee of ECB (Chair), J.Dodge (NASA, HQ), J.Janowiak (CAC, NOAA), M.Goodman (NASA, MSFC) and E.Smith (FSU) was set up to prepare the "rules of combat", and to determine how the results will be

evaluated. Invitation letters to possible PIP-1 participants were sent out in December 1991, and ancillary and validation data sets were obtained. A subsequent case-study oriented PIP-2 is now being advanced from seed to embryo.

Focus of Present Research and Plans for Next Year

Presently, we are preparing our own results for submission to PIP-1 by the deadline of 31 July 1992, and designing the statistical package by which results from all participating laboratories will be judged. From 1 August until 4 January 1993 we will, in liaison with MSFC, process and analyse these results.

It is our intention in 1993 to prepare a detailed Report on the intercomparison in time for a Participant's Workshop provisionally set for 13-14 April 1993. After this we will complete and edit a special edition of the refereed journal Remote Sensing Review (approx. 200pp) to describe PIP-1, its need, its components, and its results and their implications. For the second half of the year we hope to participate in the planned PIP-2 (case studies) exercise, and follow-on activities from PIP-1 as its results recommend, it is expected that ECB will continue to Chair the PrecipWG through this period.

Publications

Barrett, E.C. (1991): Diagnostic, historic & predictive analyses of rainfall using passive microwave image data. Palaeogeography, Palaeoclimatology & Palaeoecology, 90, 1991, p.99-106.

Barrett, E.C. & Bellerby, T.J. (in press): A strategy for the calibration by collateral data of satellite rainfall estimates for shorter periods. Accepted for publication in Journal of Applied Meteorology.

Barrett, E.C., Kidd, C. and Kniveton, D. (1992): Global Rainfall Monitoring by the SSM/I: Products, Problems and Intercomparison Projects. Final Report to USRA, Columbia, MD., RSU, Univ. Bristol, 83pp + 27pp of Plates.

Barrett, E.C., Kidd, C. & Xu, Hui. "Snow monitoring by AVHRR-HRPT and DMSP-SSM/I data analyses". In Proceedings of the Vth AVHRR Users Meeting, Tromso, Norway, 1991, p.103-108.

John R. Christy
Assistant Professor, Atmospheric Science
University of Alabama in Huntsville
and
Roy W. Spencer, NASA/MSFC

1. Microwave Sounding Unit Research (with Roy Spencer)

Papers in press:

Spencer, R.W. and J.R. Christy, 1992: Precision and radiosonde validation of satellite gridpoint temperature anomalies. Part I: MSU Channel 2. *J. Climate*, **5**.

Spencer, R.W. and J.R. Christy, 1992: Precision and radiosonde validation of satellite gridpoint temperature anomalies. Part II: A tropospheric retrieval and trends during 1979-90. *J. Climate*, **5**.

Trenberth, K.E., J.R. Christy and J.W. Hurrell, 1992: Monitoring global monthly mean surface temperatures. *J Climate*, **5**.

Papers in review

Spencer, R.W. and J.R. Christy, 1993: Precision lower stratospheric temperature monitoring with the MSU: Technique, Validation, and Results 1979-90. *J. Climate*.

Contributions to books:

Christy, J.R., "Monitoring Global Temperature Changes from Satellites". Chapter 11. *Global Climate Change: Implications, Challenges and Mitigation Measures*. Eds: S.K. Majumdar, L.S. Kalkstein, B. Yarnal, E.W. Miller, and L.M. Rosenfeld. The Pennsylvania Academy of Science.

Conference Presentations:

(invited) Spencer, R.W. and J.R. Christy, 1991: A physical interpretation of brightness temperatures observed by the Microwave Sounding Units based upon Raobs. *Fifth Symposium on Climate Variations*, American Meteorological Society, 14-18 Oct. 1991, Denver CO.

Christy, J.R. and K.E. Trenberth, 1991: Monitoring global monthly surface temperatures. *Fifth Symposium on Climate Variations*, American Meteorological Society, 14-18 Oct. 1991, Denver CO.

(invited) Christy, J.R., 1991: The MSU data, 1979 to the present. *First Demetra Meeting on Global Change*, 28 Oct. 1991, Chianciano Italy.

Other

Invited Contributor, *Climate Change 1992: IPCC,Supplementary Report (Section C,Observed Climate Variability and Change).* Melbourne Australia, 24-26 Nov. 1991.

Research areas:

Working with Spencer to develop a multi-channel retrieval for increased tropospheric precision. The problem area concerns the instability of channel 3 on at least three of the MSUs.

Using footprint data, I am constructing global synoptic maps of MSU temperatures (daily means at this point) for identification of variability over data sparse regions on the synoptic scale.

2. Earth Observing System

(In addition to papers listed above)
Papers presented:

Christy, J.R., R.T. McNider, F.R. Robertson and D. Fitzjarrald, 1991: Comparison of MSU and CCM1 tropospheric temperatures for 1979-86. *Fifth Symposium on Climate Variations,* American Meteorological Society, 14-18 Oct. 1991, Denver CO.

Christy, J.R., 1992: Climate model validation using MSU global temperatures. Workshop on Atmospheric Model Intercomparison Project. 21 Feb. 1992, Berkeley, CA.

Research Areas

One result from the multi-year run of the CCM1 using prescribed (observed) SSTs (1978-86) indicated that the model's tropospheric temperature responds to SST warming almost exactly as does the real atmosphere as measured by MSU temperatures. However, during periods of cooling, the CCM1 did not return to the levels seen in the real atmosphere so that a warm bias slowly was built in the model results. At present the net downward solar flux in the tropics is being examined and found to vary in the opposite sense from atmospheric temperature (warmer troposphere indicates more cloudiness).

This seems to be a negative feedback on temperature, though not to the extent experienced in the real world.

D. Fitzjarrald, J. Srikishen and I are studying the predictability of global stratospheric and tropospheric temperatures using neural network theory.