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VALIDATE ALGORITHMS FOR THE DETERMINATION OF RAINFALL
RATES FROM SSA/I MI. (U) WISCONSIN UNIV-MADISON SPACE
SCIENCE AND ENGINEERING CENTER. NOV 87

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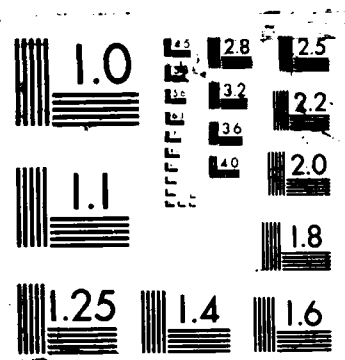
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SPACE SCIENCE AND ENGINEERING CENTER

UNIVERSITY of WISCONSIN - MADISON
1225 West Dayton Street
Madison, Wisconsin 53706

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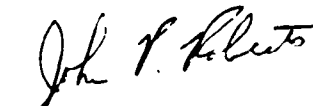
Dr. James Hollinger, Code 83-11
Naval Research Laboratory
4555 Overlook Ave., S.W.
Washington, DC 20375-5000

Dear Dr. Hollinger:

In compliance with the bi-monthly reporting requirements of Contract N00014-86-2001, entitled "Validate Algorithms for the Determination of Rainfall Rates from SSM/I Microwave Satellite Imagery", enclosed is a progress report for the months of October and November, 1987.

If you have any questions or desire further information, please contact me at (608)262-0985. Thank you for your consideration.

Sincerely,


John P. Roberts
Assistant Director

cc: Robert C. Lo, Code 7781-2 (1)
Administrative Contracting Officer, ONRRR (1)
Director, NRL (6)
Defense Technical Information Center, Code S47031 (12)
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Olson
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FINANCIAL PROGRESS REPORT

October & November 1987
Progress Period

CONTRACT NUMBER: N00014-86-^K2001

DESCRIPTION OF EFFORT: "Validate Algorithms for the Determination of
Rainfall Rates from SSM/I Microwave Satellite
Imagery"

PROGRAM MANAGER: William Olson **PHONE NUMBER:** (608) 263-4085

FUNDS ALLOCATED:	<u>\$289,998.00</u>
FUNDS ON CONTRACT:	<u>360,643.00</u>
\$ AMT THIS VOUCHER:	<u>8,852.40</u>
CUMULATIVE \$ AMT VOUCHERS SUBMITTED:	<u>274,608.31</u>
BALANCE:	<u>15,389.69</u>
COST THRU TECHNICAL REPORT PERIOD NOT VOUCHERED:	<u>\$ 23,919.53</u>

 12/22/87
Signature/Date

S/N 0104-LF-000-C

Standard Form 1034 September 1973 4 Treasury FRM 2000		PUBLIC VOUCHER FOR PURCHASES AND SERVICES OTHER THAN PERSONAL				VOUCHER NO 4-X097-23		
U.S. DEPARTMENT, BUREAU, OR ESTABLISHMENT AND LOCATION Disbursing Officer REPARTMENT OF THE ARMY Naval Research Laboratory 4555 Overlook Avenue, SW Washington, DC 20375-5000 ATTN: Code 1332 VIA: ONR			(7)		DATE VOUCHER PREPARED November 11, 1987		SCHEDULE NO	
PAYEE'S NAME AND ADDRESS Board of Regents of the University of Wisconsin System ATTN: Director, Research Administration-Financial 442 A. W. Peterson Offc. Bldg. 750 University Avenue Madison, WI 53706			CONTRACT NUMBER AND DATE N00014-86-K-2001		PAID BY		DATE INVOICE RECEIVED	
			REQUISITION NUMBER AND DATE				DISCOUNT TERMS	
							PAYEE'S ACCOUNT NUMBER	
SHIPPED FROM			TO		WEIGHT		GOVERNMENT B/L NUMBER	
NUMBER AND DATE OF ORDER	DATE OF DELIVERY OR SERVICE	ARTICLES OR SERVICES (Enter description, item number of contract or Federal supply schedule, and other information deemed necessary)			QUAN- TITY	UNIT PRICE COST PER		AMOUNT
	10/1/87 to 10/31/87	For detail, see SF 1035, Continua- tion Sheet, total amount claimed transferred from page 1 of SF 1035. cc: Dr. James A. Weinman Gwendolyn V. Taylor John P. Roberts Marie Spangler						\$8,852.40
(Use continuation sheet(s) if necessary) (Payee must NOT use the space below) TOTAL								\$8,852.40
PAYMENT <input type="checkbox"/> COMPLETE <input checked="" type="checkbox"/> PARTIAL <input type="checkbox"/> FINAL <input type="checkbox"/> PROGRESS <input type="checkbox"/> ADVANCE	APPROVED FOR Provisional = \$ Payment subject to later audit BY ? Gwendolyn V. Taylor TITLE Procurement Assistant Offc. of Naval Research		EXCHANGE RATE \$1.00		DIFFERENCES			
Pursuant to authority vested in me, I certify that this voucher is correct and proper for payment								
(Date)		(Authorized Certifying Officer's)				(Title)		
ACCOUNTING CLASSIFICATION								
Appropriation Symbol and Subhead	Object Class	Bureau Control and Suballot. No.	Auth. Acctg. Activity	Type	Property Acctg. Actv.	Cost Code	Amount	
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1 When stated in foreign currency, insert name of currency 2 If the ability to certify and authority to approve are combined in one person, one signature only is necessary other- wise the approving officer will sign in the space provided over his official title 3 When a voucher is receipted in the name of a company or corporation, the name of the person writing the company or corporate name as well as the capacity in which he signs, must appear. For example: "John Doe Company, per John Smith, Secretary", or "Treasurer", as the case may be						PER		
						TITLE		

Standard Form No. 1035 7 GAO 5000 1035-108-01		PUBLIC VOUCHER FOR PURCHASES AND SERVICES OTHER THAN PERSONAL CONTINUATION SHEET				VOUCHER NO 4-X097-23
						SCHEDULE NO
						SHEET NO 1
U.S. DEPARTMENT, BUREAU, OR ESTABLISHMENT Dept. of NAVY						
NUMBER AND DATE OF ORDER	DATE OF DELIVERY OR SERVICE	ARTICLES OR SERVICES <i>(Enter description, item number of contract or Federal supply schedule and other information deemed necessary.)</i>	QUAN- TITY	UNIT PRICE		AMOUNT
				COST	PER	
		Contract No.: N00014-86-K-2001 <div style="text-align: right;"> Target/Estimated Costs \$289,998.00 Target/Fixed Fee -0- Total Contract Value <u>\$289,998.00</u> </div> <u>Analysis of Claimed Current and Cumulative Costs and Fee Earned</u>				
				Amount For Current Period Billed		Cumulative Amt. From Inception To Date of This Billing
		<u>Major Cost Elements:</u> Salaries and Wages Fringe Benefits Materials & Supplies Equipment Travel Other Tuition Remission		-0- -0- -0- 1,651.95 -0- 5,036.30 -0-		34,122.94 1,841.24 -0- 13,647.20 -0- 141,577.56 7,094.68
		Total Overhead - 43% of MTDC		\$6,688.25 2,164.15		\$198,283.62 76,324.69
		Total Amounts Claimed		<u>\$8,852.40</u>		<u>\$274,608.31</u>

Progress Report for October / November 1987

Since the end of September, our primary activities have been (a) amassing an extensive catalog of radar and raingage data over our primary and secondary validation sites (~~see Appendix~~) that correspond to SSM/I overpass times occurring between July 19 and Sept. 30, 1987, (b) ordering radar and calibrating raingage data for cases in this catalog, (c) ordering the SSM/I data for the same cases, (d) writing the software necessary for unpacking calibrated rain data from the United Kingdom, (e) upgrading the navigation of radar bins, based upon the geometry of radar beam propagation and the geodetic formulae of Sodano (*Bull. Geodesique*, 1965), and (f) imaging the 25 km resolution radar rain rate fields produced by our data merging programs (see Validation Software section). We are just beginning to analyze the radar data from our primary validation sites, comparing this data with the limited number of orbits of SSM/I data so far received. We are also continuing our cooperation with scientists of the Severe Storms Branch of NASA/Goddard Space Flight Center in order to expedite the radiative transfer modeling necessary for the analysis and improvement of the current rain rate algorithm.

Validation Data

We are beginning to collect high spatial- and temporal-resolution radar and raingage data from the primary validation site at Marshall, CO. The radar data are from the CP2 Doppler radar, and the raingage data are from the (PROFS) Mesonetwork of gages in north-central Colorado. We possess data for three cases and have ordered data for four more cases. Including secondary validation sites, our catalog contains over 180 radar-observed rain events at midlatitudes in



Availability Codes	
Dist	Area and/or Special
A-1	

the United States that coincide with SSM/I overpasses.

We have received radar data from two cases at the primary validation site at Patrick AFB (Cape Canaveral), FL, with data from three more cases on order. We have identified over 70 rain cases in the subtropics with coincident SSM/I and radar/raingage coverage.

We have also received gage-calibrated radar data and calibrating raingage observations for the entire month of August, 1987, from the British Meteorological Office's network of six radars in the United Kingdom. Approximately 30 moderate- or heavy-rain cases have been identified which were covered by at least one of the network radars during SSM/I overpasses through Sept. 30.

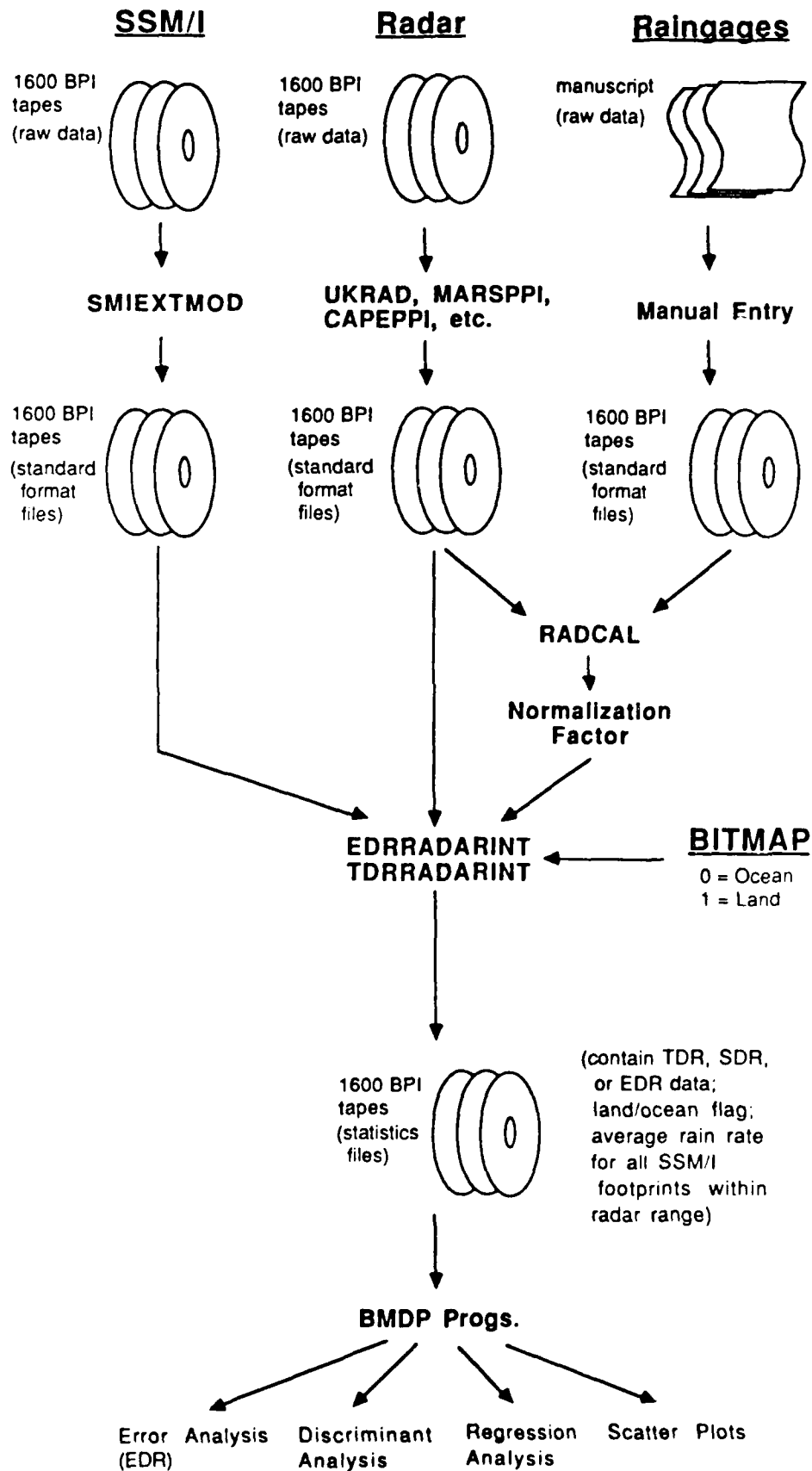
Acquisition of data from the Canadian radars and raingages will begin shortly.

In total, over 350 significant rain cases coinciding with both SSM/I overpass and coverage by the primary or secondary radars have been identified by our team of weather analysts. Contact with Australian authorities for data from the 5 Australian radars is currently underway. The outlook is good for acquisition of both radar and raingage data from the Australian sites in the near future. This is particularly important because the Darwin site is our only source of tropical rain data having sufficient quality for quantitative analysis.

Validation Software

A processing flow chart for data utilized in the SSM/I rain rate retrieval validation is shown on the following page. Software for unloading and processing the SSM/I data (SMIEXTMOD) and the radar (UKRAD, etc.) and raingage data issued from the primary validation sites has been completed. At present the standard format files created by the unpacking programs would be stored on magnetic tape to await subsequent processing.

Schematic for SSM/I Validation



Data in the standard format files is merged to create statistics files using EDRRADARINT and TDRRADARINT. A radar rain rate normalization factor is computed using radar and coincident raingage observations (RADCAL) and input to the merging procedure to calibrate rain rates derived by radar at the SSM/I overpass time. A 5 n. mi. resolution bitmap is also called during the merging procedure to determine whether or not a given SSM/I footprint is over land or ocean. To date, the merging routines are operational and the bitmap can be accessed by these routines. The RADCAL procedure for determining the radar normalization factor should be completed shortly, pending a decision on what type of ground truth rain rate product is most appropriate for validation (see Future Plans and Goals section).

Statistics files resulting from the file merge would again be stored on magnetic tape. BMDP subroutines can then be invoked to statistically analyze the TDR, SDR, EDR, and rain rate ground truth data. The BMDP software package is currently on line.

Future Plans and Goals:

During the next two months we expect that all validation software will be completed, and that we will have received enough SSM/I and ground truth data to statistically evaluate the current rain algorithm performance at our primary validation sites, at least for seasons during which the SSM/I is operating. A final decision will be made as to whether gage-calibrated rain rates derived from low-level PPI scans, CAPPI scans or both will be utilized in the algorithm validation. This decision will be based upon both a comparison of radar-derived rain rates from both PPI's and CAPPI's to raingage totals and an assessment of the availability of both types of data.

Regardless of the type of ground truth used, the large volume of satellite and radar data required for the validation will probably make it necessary to utilize an optical disk in order to store standard format, statistics, and image files. Optical disk storage is a cost-effective and space-saving alternative to magnetic tape for permanent file storage, and it allows faster access to data. The Vax computer system we have been using in the validation effort is equipped with an optical disk drive and controlling software which are used routinely.

As soon as sufficient data are received, alternative statistically-based algorithms will be developed and evaluated. Modeling support for alternate algorithm development will be provided in part by our colleagues at the Severe Storms Branch of GSFC.

Appendix

Validation Sites (* indicates primary sites)

U. S. (Midlatitudes)

Marshall, CO*
Limon, CO
Amarillo, TX
Garden City, KN
Wichita, KN
Oklahoma City, OK
Monett, MO
Nashville, TN

U. S. (Subtropics)

Cape Canaveral, FL*
Tampa, FL

Canada (N. Midlatitudes)

Exeter, ONT
Carp, ONT
Montreal, QUE
Villeroy, QUE
Trepassey, NFLD

United Kingdom (N. Midlatitudes)

Hameldon Hill, Lancashire*
Chenies, Buckinghamshire*
Clee Hill, Shropshire*
Camborne, Cornwall*
Upavon, Wiltshire*
Shannon, Eire*

Australia (Tropics, Subtropics, Midlatitudes)

Darwin, NA	Perth, WA	Hobart, TAS
Sydney, NSW	Melbourne, VIC	

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