NASA Technical Memorandum 87736

Archival of Seasat-A Satellite Scatterometer Data Merged With In Situ Data at Selected, Illuminated Sites Over the Ocean

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SUMMARY

A large data base of Seasat-A Satellite Scatterometer (SASS) measurements that were merged with high-quality surface-truth wind, wave, and temperature data has been documented. The data base was developed for all times when selected in situ measurement sites were within the SASS footprint. Data were obtained from 42 sites located in the coastal waters of North America, Australia, Western Europe, and Japan and were assembled by correlating the SASS and surface-truth measurements in both time and distance. These data have been archived on a set of nine-track 6250 bpi ASCII coded magnetic tapes, which are available from the National Technical Information Service.

INTRODUCTION

On July 10, 1978, NASA launched Seasat-A (later renamed Seasat-1), which was a satellite designed to demonstrate the utility of microwave remote sensors to measure the ocean-surface parameters. After taking systematic remote measurements in orbit for 100 days, the satellite failed prematurely on October 10, 1978.

Data from one of Seasat-A's experimental sensors, the Seasat-A Satellite Scatterometer (SASS), have been presented in this report. SASS is a microwave scatterometer that was designed to infer the neutral stability wind vector in the near-surface boundary layer from the normalized radar cross section (refs. 1 through 5). Earlier studies (refs. 6 and 7) used collocated and contemporary surface in situ data to evaluate the performance and upgrade the inversion algorithm of this sensor. Those studies, however, were confined to localized regions in the Coastal United States and Great Britain for periods of 1 month or less.

The assembly of SASS and surface in situ measurements into a functional data base from a set of high-quality weather-measuring sites over a much more extensive sample of the Earth's oceans is described in this paper.

SYMBOLS AND ABBREVIATIONS

d	distance from in situ site to center of SASS footprint
θ	incidence angle, deg
σ°	normalized scattering coefficient
ϕ	azimuth angle, deg
EDIS	Environmental Data and Information Service
GDR	Geophysical Data Records
NDBO	National Data Buoy Office
NESS	National Environmental Satellite Service
NSD	normalized standard deviation

OSV ocean station vessel

SASS Seasat-A Satellite Scatterometer

WMO World Meteorology Organization

SURFACE-TRUTH DATA BASE

Site Selection

The sites for collection of in situ data were selected from a large list of stations with in situ of known quality, as suggested by the ad hoc SASS Experiment Team (ref. 1). The site selection criteria included that locations should (1) be offshore; (2) maintain a periodic recording of in situ data; (3) use calibrated anemometers, temperature sensors, and wave measurements (optional); and (4) be accessible to data collection. This study was further limited to stationary sites because of the difficult logistics of obtaining hit times for two moving targets. (Hit times are defined as times when the SASS data occur in the vicinity of surface-truth sites.) A set of 61 sites was selected from which to gather surface-truth data and determine the corresponding illumination times from SASS (ref. 8).

Data Assembly

Gathering of the surface-truth data from the selected sites was a time-consuming task. The NOAA-National Environmental Satellite Service (NESS) had been instrumental in planning data assembly but when Seasat-A failed, their efforts terminated. Some of the data were readily available, while other data required extensive efforts to acquire. Some of the data that were gathered from the industrial research sites by the Seasat Program Office at the Jet Propulsion Laboratory (JPL) apparently had been lost (private communication, Donald Montgomery, JPL, Pasadena, California, June 9, 1982). Other data, such as that from oil research towers archived by Marine Explorations, Ltd. (MAREX), proved to be unavailable for our research (private communication, W. B. Wallen, United Kingdom Oceanographic Committee, February 3, 1983).

Table I summarizes the sites for surface-truth data used in this investigation, and table II gives the parameters measured and anemometer characteristics found. The locations of the data sites are given in figure 1. Of the original 61 sites, useable data were obtained for 41 sites. General comments are given concerning assembly of the in situ data.

1. The National Data Buoy Office (NDBO) data were initially obtained by John Wilkerson of NOAA-NESS from the NOAA-Environmental Data and Information Service (EDIS) in Asheville, North Carolina, and were processed by the CUNY Department of Oceanic and Atmospheric Science to calculate the corresponding neutral stability wind speed at a 19.5-m altitude. It was discovered in the Fall of 1986 that these tapes contained data formatted by NDBO to convert surface winds to knots and to round off all surface-truth data. As a result, a second set of surface-truth data tapes, containing data as measured, were obtained from Michael Freilich of JPL, and were used to reprocess all the buoy data to obtain the results given herein. Only 16 of these sites provided any useable data (table II).

2. The ocean station vessel (OSV) data were readily obtained directly from the NOAA-National Climatic Center. The anemometer types and heights were not available

from NOAA, however, and therefore these data were determined from ship registries, which were obtained from the countries that manned the stations. Tapes of the complete World Meteorology Organization (WMO) data format were obtained for five of these sites. Other ocean station vessels were no longer in service during the Seasat-A data collection period.

3. The Japanese buoy data were obtained by Peter Black of the NOAA-National Hurricane Environmental Marine Laboratory from the Japanese Meteorology Association through a Seasat United States-Japan exchange program. The products obtained were listings of data recorded every 3 hours from only 3 buoys; two of the buoys provided useable data that corresponded to the side swath of the SASS, and one buoy provided data at nadir angles only.

4. The Australian buoy data were obtained from T. D. Keenan of the Australian Department of Science and Technology, through the assistance of Greg Holland of the University of Colorado in Boulder, Colorado. The media used were standard magnetic tapes of hourly and daily surface climatic records. The data record is similar to the WMO format.

5. Data from the oil research towers varied in quantity and number of parameters (tables I and II). Data from the S5 and S10 sites were provided by Chris Hill of Dome Petroleum, Ltd. in Calgary, Alberta. Data from S9 were obtained from Bill Siapno of Deepsea Ventures, but there were no corresponding SASS overflights (S8 was an erroneous location). Data for the S11 and S12 sites were obtained from John D. Miller of Petro Canada, Calgary, Alberta. The S13 weather buoy data for October 5 through October 9, 1978, were obtained from L. G. Spedding of ESSO Resources Canada, Ltd.

SASS DATA

Measurements of the SASS normalized scattering coefficient σ° and the engineering unit parameters necessary to calculate the σ° had been recorded by the Seasat-A project and are available on magnetic tapes from NOAA-EDIS. These data files are called SASS Geophysical Data Records (GDR), see reference 9 for description, and each tape contains data from 6 hours of the mission. Certain data recorded on these tapes have subsequently been found to be incorrect or incomplete or to have used less accurate algorithms for their derivation. As a result, the Canadian Atmospheric Environment Service (Steve Peteherych) and NASA sponsored a second set of archival tapes that contained a selected set of key parameters and corrections for these errors. Improvements included

1. Corrections for beam azimuth errors that are most noticeable at the outer swath for high latitudes

2. Corrections for errors in computing the average noise temperature for the system, including contributions from cells over land

3. An additional quality flag to show out-of-range noise temperatures

4. Corrections of all received power calculations using a more accurate algorithm for computing the system mean noise power

5. The use of unnormalized signal standard deviation to improve the accuracy of recording levels near zero

The GDR files give SASS measurements ordered in 50-km by 50-km elements on a grid parallel and perpendicular to the satellite swath (the SASS GDR's are organized by the times of the forward SASS beam). A reduced set of parameters and the use of a grid allowed the σ° data set to be recorded on 16 6250 bpi ASCII magnetic tapes. These tapes, which are known as the Canadian Ordered Sensor Tapes, provided a convenient way to extract data at a specified time over a known site, and were therefore used to generate the SASS/surface-truth data base.

EXTRACTION AND MERGE OF SASS AND SURFACE-TRUTH DATA

The processing necessary to extract and merge the SASS and surface-truth data is shown in the flow diagram of figure 2. Surface-truth processing included

1. Time interpolation of the wind speed and wind direction data if both measurements were within ±180 min of the hit time

2. Conversion to neutral stability wind speed at a 19.5-m altitude using the Monin-Ubokov boundary layer theory (ref. 10); the subroutine used in this process was from W. J. Pierson, City College of the City University of New York (CUNY)

3. Identification of parameters or processes that were incomplete or absent and the assignment of a flag to data that required qualification; surface-truth quality flags were provided to indicate

    1. No wind direction data
    2. No air and sea temperature (no stability correction)
    3. No air or sea temperature (zero stability correction)
    4. Relative humidity assumed to be 75 percent
    5. No interpolation, only one measurement
    6. No wind speed measurement within 90 min of the hit time

For SASS data, the hit times and locations were used to find the corresponding exact 50-km by 50-km bin from the Canadian Ordered Sensor Tapes. The SASS measurements from a 5- by 5-array of bins centered on this bin were extracted next for each hit time and were screened to retain only the data within 150 km of the surface-truth site locations. The SASS measurements were excluded if appropriate SASS quality bits indicated the items listed below.

Flags	Description of data excluded
1, 2	Any land was viewed by sensor
5, 6	Sensor detector voltage out of range
10	Antenna angle was out of range
4, 11, 13, 15, and 9 on/14 off	System noise temperature was out of range
7	Received power and scattering cross section were less than zero
16	Scattering cross section equaled -199.9 dB, or the incidence angles for the frame did not increase monotonically

Details of the elements of the merged information and the format of the merged files are given in the appendix. A typical partial listing of one such file, read with the READTP code from the appendix, is shown in figure 3. For each site, the site name, location, and anemometer characteristics are given in the top headnote. For each hit, the hit time and in situ data are given in the second headnote followed by a listing of parameters from all the SASS measurements that are within 150 km of the hit.

These data from all sites have been archived on a set of four 6250 bpi ASCII magnetic tapes and are available from NTIS and the Jet Propulsion Laboratory. Copies of these tapes are available upon request. Requestors should ask for the Data Tape Supplement to NASA TM-87736.

RESULTS AND CONCLUDING REMARKS

The merge of these data sets resulted in a sizeable data base with samples from a significant portion of the world's oceans (fig. 1). Table III gives the number of hit times for each of the measured sites; this number includes both nadir and off-nadir hit times. Figure 4 presents histograms for the distribution of the in situ wind speeds and the level of the σ° of SASS measurements for the merged file containing 70 749 samples of the vertical polarization data. (The horizontal polarization data set distribution is similar to that of the vertical polarization data set.) The number of hits and the wind speed range provide a significant sample set. These data should prove useful to investigate further the nature of radar backscatter from the ocean surface in the 14.6-GHz frequency band used by SASS and to improve future scatterometer skill in deriving ocean-surface wind vectors (ref. 11).

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TABLE I.- SURFACE-TRUTH SITES

Site no.	Lat., deg N	Long., deg E	(a)	Comments
U.S. NDBO buoys				
B1 - 41001	35.0	288.0	196-282	
B2 - 41002	32.3	284.7	196	(b)
B3 - 41004	32.6	282.0		All[c]
B4 - 42001	26.0	270.0	196-281	
B5 - 42002	26.0	266.5	196-280	[b]205-228
B6 - 42003	26.0	274.0	196-282	
B7 - 44001	38.7	286.4	212-282	
B8 - 44002	40.1	287.0		All[b,c]
B9 - 44003	40.8	291.5	220-282	
B10 - 44004	39.0	290.0	196-282	
B11 - 46001	56.0	212.0	267-279	[c]196-265
B12 - 46002	42.5	230.0	195-281	
B13 - 46003	52.0	204.0	195-198	[b,c]202-283
B14 - 46004	51.0	224.0	261-282	[b,c]196-258
B15 - 46005	46.0	229.0	196-282	
B16 - 46006	41.0	222.0	195-282	
B17 - 46007	59.2	207.3	228-282	
B18 - 46008	57.1	208.3	200-282	[b]245-278
B19 - 46009	60.2	213.2	196-253	[b]253-283
Ocean station vessels (weather ships)				
WS1 - Ami	71.3	19.0		No data station
WS2 - Charlie	52.45	324.3		No data station
WS3 - Kiefumara	20.0	130.0		No data station
WS4 - Lima	57.0	340.0	204-282	
WS5 - Mike	66.0	2.0	203-282	
WS6 - Papa	50.0	215.0	205-281	
WS7 - Romeo	47.0	343.0	203-282	
WS8 - Tango	29.0	135.0	204-237	(b)
Japanese data buoys				
J3	25.67	135.93	195-273	
J4	28.33	126.08	240-272	All Nadir hits[b]
J6	37.75	134.4		Not in operation
J7	39.5	145.5	195-209	(b)

[a]Numbers indicate day-of-year range for which SASS/surface-truth hits occurred.

[b]Surface truth missing.

[c]Hits not generated because NDBO buoy status reports indicated unuseable surface-truth data that was later recovered. Number gives period of data lost.

TABLE I.- Concluded

Site no.	Lat., deg N	Long., deg E	(a)	Comments
Australian data buoys				
A1 - Scott Reef	-14.03	121.48		All[b]
A2 - Browse Island	-14.07	123.3	193-282	[b]194-244
A3 - Rowley Shoals	-17.3	118.54	193-282	
A4 - Adele Island	-15.3	123.09	192-282	
A5 - Holmes Reef	-16.29	147.53	189-282	
A6 - Flinder Reef	-17.43	148.29	189-282	
A7 - Lihou Reef	-17.07	152.01	188-201	(b)
A8 - Willis Island	-16.18	149.59	188-281	
A9 - Marion Reef	-19.06	152.23	188-281	
A10 - Creal Reef	-20.32	150.23	188-281	
A11 - Cannet Cay	-21.57	152.28	188-281	
A12 - Frederick Reef	-20.57	154.25	189-282	
A13 - Cato Island	-23.15	155.32	189-197	(b)
Ocean oil/commercial research towers				
S1 - Union/Conoco	59.55	1.58		Data unavailable
S2 - Union/Conoco	61.07	1.72		" "
S3 - Union/Conoco	57.75	.92		" "
S4 - Union/Conoco	60.13	357.0	230-281	" "
S5 - Kopanoar/ESSO	70.02	225.68		(b)
S6 - Conoco Exp. 4	37.31	13.54		Wrong location used
S7 - Getty Exp. 5	37.0	15.0		" " "
S8 - Deepsea Ventures	15.0	125.0		Erroneous site
S9 - Deepsea Ventures	15.0	235.0		All[b]
S10 - Explorer/Dome	70.17	227.25	230-282	(b)
S11 - Pelerin/Skolp	58.43	298.23	205-272	
S12 - Pelerin/Roberval	54.85	304.27	275-282	(b)
S13 - Asiak/ESSO	61.67	299.42	278-281	(b)
P21 - Oil rig	29.7	271.1		Data unavailable
P22 - Oil rig	29.1	269.5		" "
P26 - Oil rig	28.5	267.8		" "
P30 - Oil rig	28.3	267.0		" "

Summary of contributing data sites	
No hits generated	2
In situ unavailable	14
Wrong site location used	3
Data obtained and used	42

[a]Numbers indicate day-of-year range for which SASS/surface-truth hits occurred.

[b]Surface truth missing.

[c]Hits not generated because NDBO buoy status reports indicated unuseable surface-truth data that was later recovered. Number gives period of data lost.

TABLE II.- SURFACE-TRUTH PARAMETERS AND ERRORS

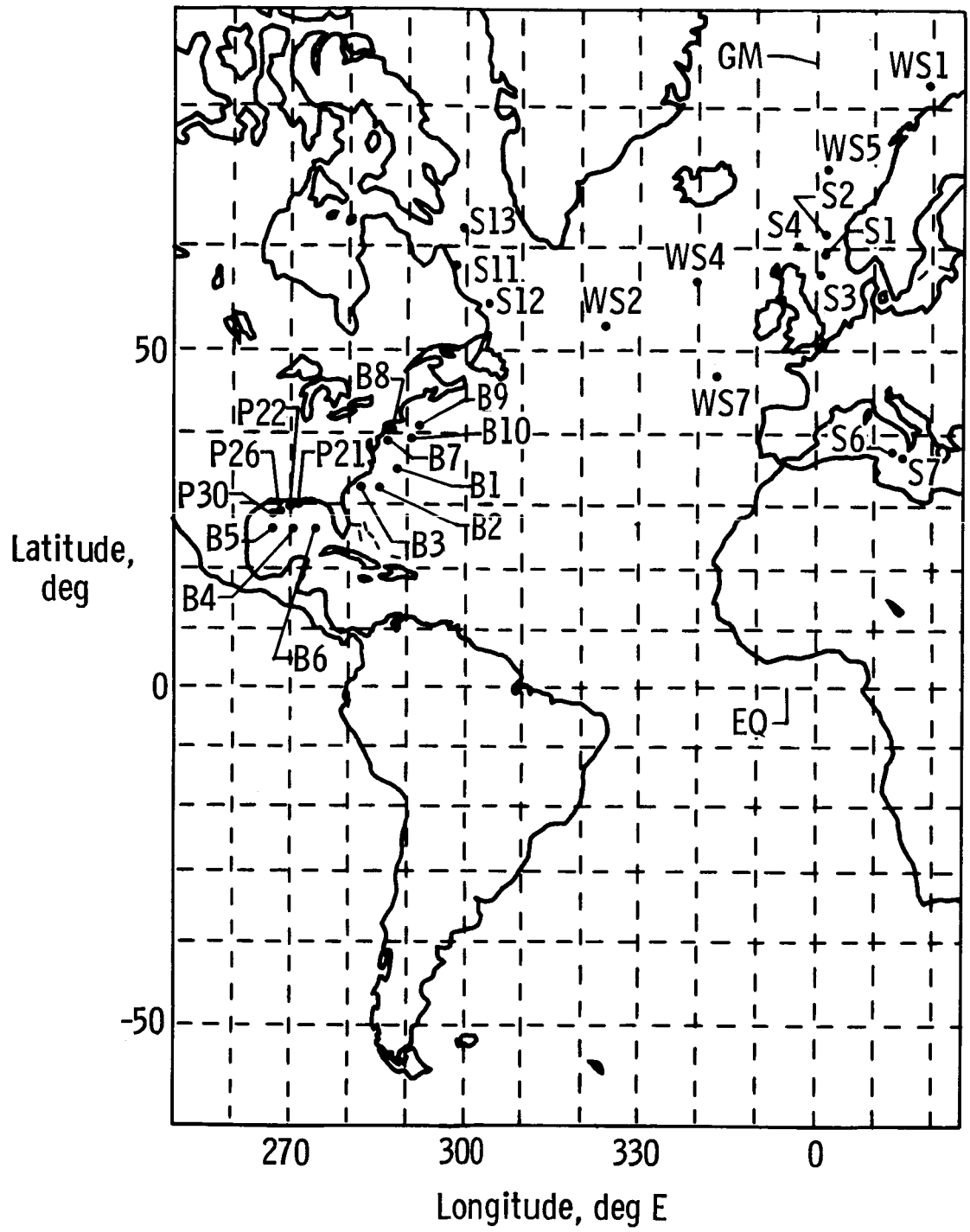
Site	Parameters recorded														Anemometer characteristics			
	Wind		Temperature				Barometric pressure	Weather code	Wave			Swell			Speed error, m/s	Dir error, deg	Integration time, min	Height, m
	Speed	Direction	Air	Sea	Wet	Dew			Height	Direction	Period	Height	Direction	Period				
NDBO	x	x	x	x			x		x	x	x				1	15	10	5 or 10
Ocean Sta X	x	x	x	x	x	x	x	x	x	x	x	x	x	1	1	15	[a]10	(b)
Japan Buoys	x	x	x	x	x		x		x		x				1.5	15	10	7.5
Australian[c]	x	x	x		x	x	x	x	x			x	x		1.5	20	8.5	(d)
S5	x	x	x	x	x		x	x	x		x	x	x	x	[e]1.5	20	?	12.2
S9	x	x	x	x			x	x	x			x	x		[e]1.5	20	?	?
S10	x	x	x	x	x		x	x	x		x	x	x	x	[e]1.5	20	?	19.5
S11, S12	x	x	x	x	x	x	x		x		x	x	x	x	1.5	20	1	32.3
S13	x	x	x	x			x		x		x				[e]1.5	20	?	10

[a] Spot recordings at Lima.
[b] WS4 22, WS5 (Cumulus) 22, WS5 (Polaris) 16, WS6 (Vancouver) 24.7, WS6 (Quadra) 22, WS8 11.5.
[c] Rain data also recorded.
[d] All 10 m except A2 (11 m), A8 (12 m), and A10 (13 m).
[e] Anemometer accuracy estimated for S5, S9, S10, and S13.

TABLE III.- COUNT OF DATA SAMPLES OF SASS MERGED WITH IN SITU DATA

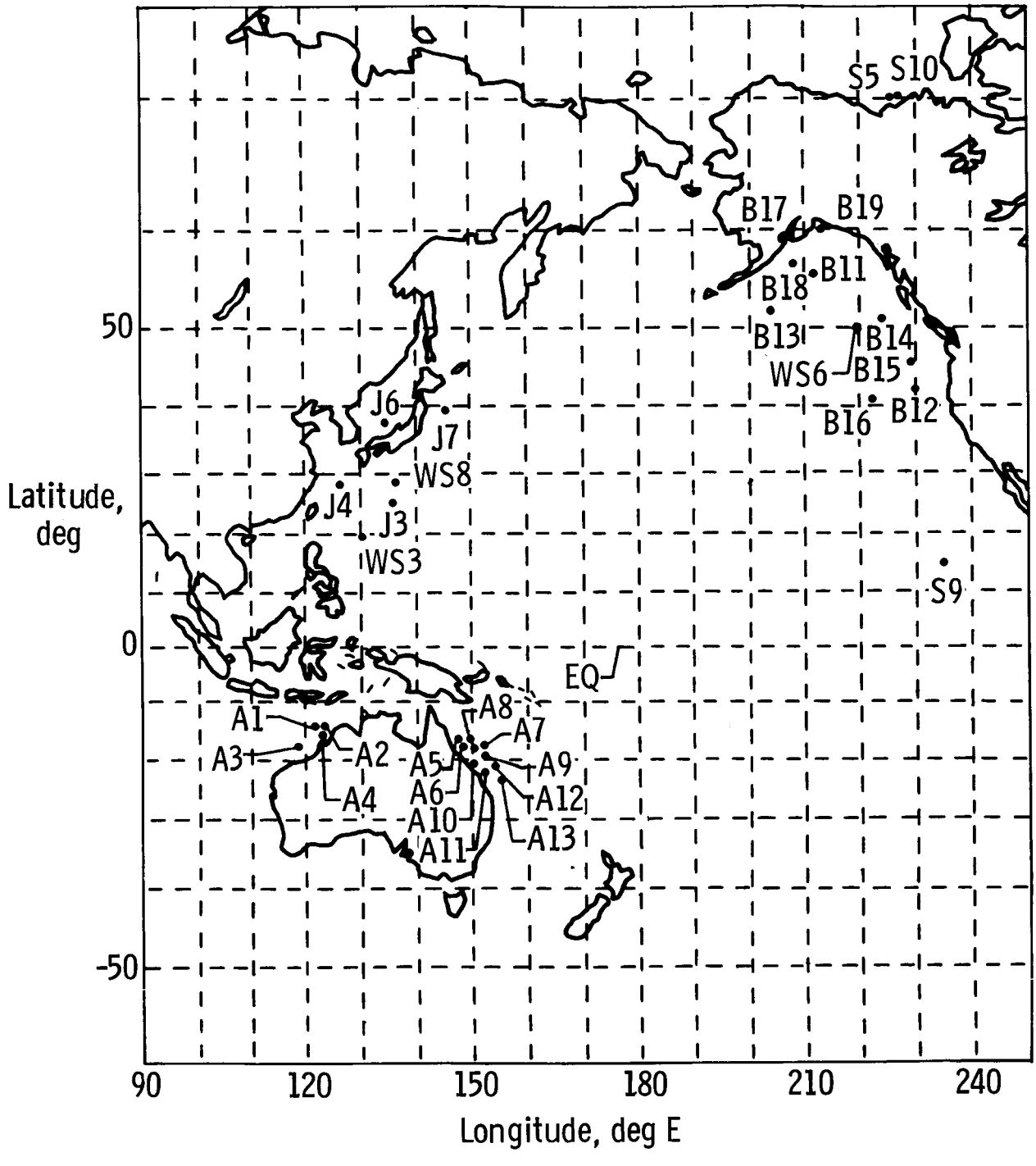
Site no.	Merge times		SASS surface-truth data samples		
	Total	No SASS measurements*	V-pol	H-pol	Total
Tape SASST1					
A2	64	6	1257	37	1294
A3	109	13	3081	296	3377
A4	122	20	2571	147	2718
A5	126	15	3141	168	3309
A6	125	38	3024	85	3109
A7	112	15	3548	256	3804
A8	131	13	4273	280	4553
A9	116	15	3877	344	4221
A10	109	20	3715	176	3891
A11	113	20	3472	168	3640
A12	146	18	3618	258	3876
A13	12	2	302	83	385
B5	46	10	1604	1120	2724
B6	80	17	2792	2315	5107
B7	78	20	2520	2443	4963
B9	66	7	2385	2298	4683
B10	93	9	3483	2559	6042
B11	26	3	710	566	1276
B12	97	14	3952	2963	6915
B13	6	0	343	0	343
Tape SASST2					
B14	29	15	458	441	899
B16	75	11	2505	1676	4181
B17	95	22	3042	2600	5642
B18	85	31	2494	2021	4515
J3	69	4	2722	102	2824
J4	21	1	1175	0	1175
J7	82	3	3671	391	4062
S5	126	9	4527	4292	8819
S10	126	9	4251	4277	8528
S11	79	14	2521	2272	4793
S12	10	1	322	317	639
Tape SASST3					
S13	7	0	274	282	556
W4	148	11	5632	5544	11 176
WC5	161	14	5902	5588	11 490
WP5	143	5	5273	4800	10 073
W6Q	34	1	1094	972	2 066
W6V	41	2	1555	1338	2 893
W7	77	7	2658	2145	4 803
W8	45	2	2367	36	2 403
Tape SASST4					
B1	76	64	173	149	322
B2	1	1	0	0	0
B4	84	29	2009	1464	3473
B15	109	63	746	504	1250
B19	97	78	509	427	936
Totals	3517	655	109 548	58 200	167 748

*Within 150 km



(a) Atlantic region.

Figure 1.- Location of surface-truth sites of this study (ref. 8). Site designations correspond to those listed in table I.



(b) Pacific region.

Figure 1.- Concluded.

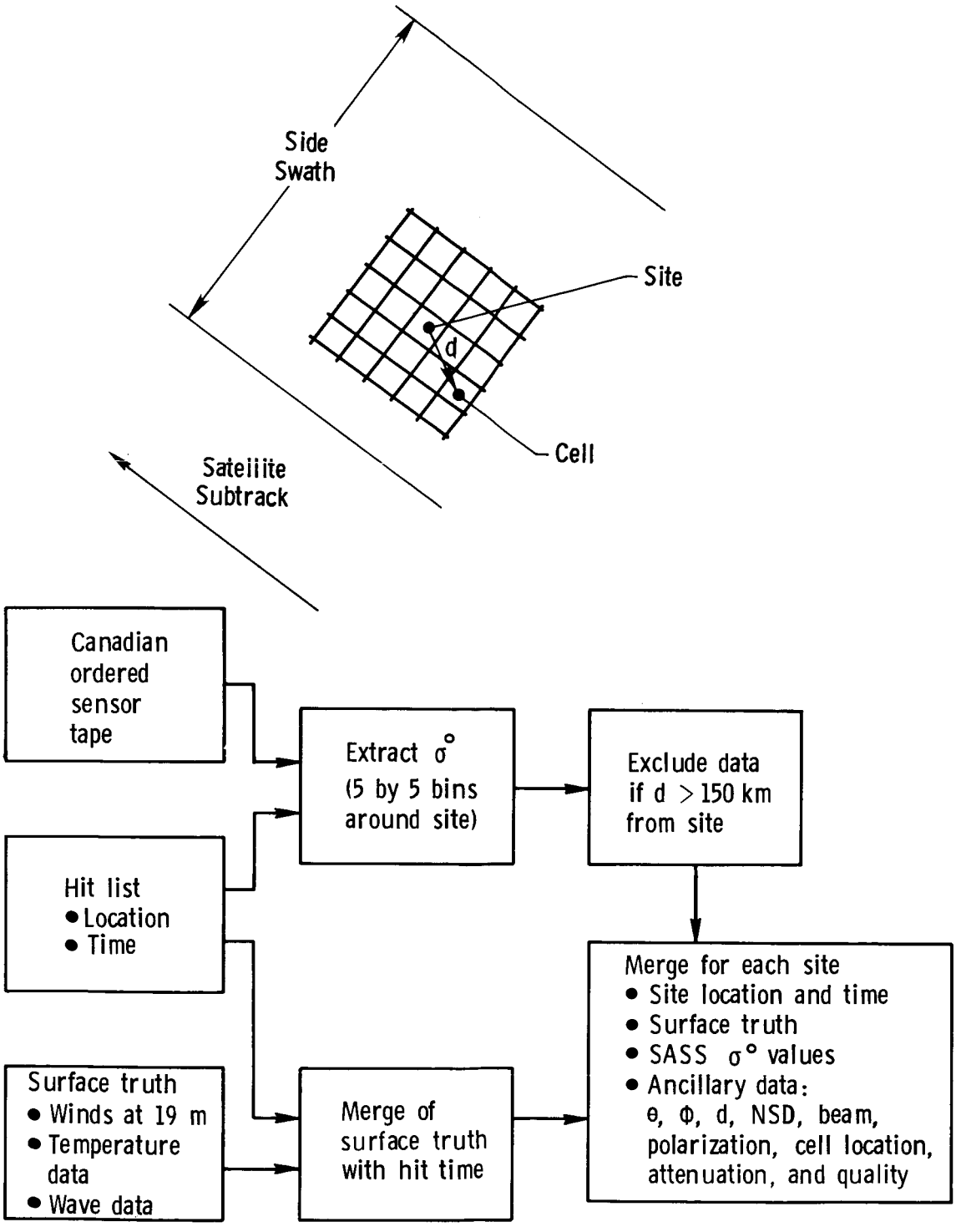


Figure 2.- SASS/surface-truth data merge for hit list.

JAPANESE BUOY NO. 3 LAT = 25.1, LON = 135.2, ANEMOMETER HGHT = 7.5M, MEASUREMENTS AVGED OVER 8 MIN

HIT TIME DDD HH MM SS	WSP 19.5M	WDR	TEMP DEG C AIR	SEA	WET	DEW	AIR PRESS	WEATHER PRESENT	PAST	WAVE HT	DIR	PER	SWELL HT	DIR	PER	AUST WAVE INFO	RAIN MM	QUALITY 123456
195:20:21: 2	11.1	20	27.1	-99.0	24.1	-99.0	1004.7	-99	-99	2.3	-99	7.1	-99.0	-99	-99.0	-99	-99.0	001000

50K BIN	MODE	BEAM	POL	CELL	TIME	LAT	LON	DIST	INCD	AZ	SIGZ	TSDDB	NSD%	ATT	QUALITY BITS
29	1	2	1	4	20:21:45	23.97	134.63	138.32	33.83	117.20	-13.65	-26.5	5.2	.08	0000000000000100
29	1	2	1	5	20:21:53	24.15	134.98	108.01	37.37	117.30	-16.13	-29.5	4.6	.08	0000000000000100
30	1	2	1	6	20:21:53	23.91	135.50	135.83	40.55	117.48	-17.70	-31.4	4.3	.08	0000000000000100
30	1	1	1	3	20:20: 3	24.01	135.24	121.34	35.16	26.93	-10.35	-23.4	5.0	.08	0000000000000100
31	1	2	1	7	20:22: 0	24.10	135.82	127.71	43.44	117.67	-17.99	-31.8	4.1	.08	0000000000000100
31	1	1	1	4	20:19:56	24.25	135.79	111.81	39.74	27.09	-11.76	-26.2	3.6	.07	0000000000000100
32	1	1	1	5	20:19:48	24.50	136.35	133.96	44.01	27.21	-13.05	-28.2	3.0	.09	0000000000000100
32	1	2	1	8	20:22: 8	24.29	136.11	128.77	46.02	117.87	-18.33	-31.9	4.4	.10	0000000000000100
32	1	2	1	9	20:22:15	24.49	136.39	138.02	48.37	118.04	-19.13	-31.9	5.2	.10	0000000000000100
28	1	2	1	3	20:21:45	24.22	134.08	149.69	30.03	117.06	-11.33	-23.3	6.4	.08	0000000000000100
29	1	1	1	2	20:20:18	24.21	134.50	121.71	30.21	26.72	-8.02	-19.8	6.6	.08	0000000000000100
29	1	2	1	4	20:21:53	24.40	134.45	108.66	33.87	117.13	-13.24	-26.1	5.2	.08	0000000000000100
29	1	2	1	5	20:22: 0	24.59	134.79	70.23	37.37	117.28	-15.44	-29.0	4.4	.08	0000000000000100
30	1	1	1	3	20:20:11	24.44	135.05	74.97	35.14	26.88	-10.83	-23.9	5.0	.08	0000000000000100
30	1	2	1	6	20:22: 0	24.33	135.31	86.38	40.54	117.47	-16.65	-30.6	4.0	.08	0000000000000100
31	1	2	1	7	20:22: 8	24.52	135.63	77.78	43.41	117.68	-17.06	-31.2	3.9	.08	0000000000000100
31	1	1	1	4	20:20: 3	24.68	135.61	62.41	39.76	27.09	-12.21	-26.6	3.6	.07	0000000000000100
32	1	2	1	9	20:22:23	24.92	136.22	104.77	48.40	118.01	-18.54	-31.6	5.0	.08	0000000000000100
32	1	1	1	5	20:19:56	24.94	136.17	99.40	44.06	27.23	-13.43	-28.6	3.1	.07	0000000000000100
32	1	2	1	8	20:22:15	24.72	135.93	84.93	46.02	117.86	-17.81	-31.6	4.2	.07	0000000000000100
33	1	2	1	10	20:22:31	25.13	136.49	129.99	50.55	118.19	-18.55	-31.0	5.7	.00	0000000000000100
28	1	2	1	3	20:21:53	24.66	133.90	140.04	30.06	116.97	-11.13	-23.1	6.4	.08	0000000000000100
29	1	1	1	2	20:20:26	24.66	134.32	101.41	30.27	26.78	-8.38	-20.2	6.6	.07	0000000000000100
29	1	2	1	4	20:22: 0	24.83	134.26	99.45	33.86	117.11	-13.50	-26.3	5.2	.07	0000000000000100
29	1	2	1	5	20:22: 8	25.01	134.60	61.29	37.34	117.30	-14.65	-28.3	4.3	.07	0000000000000100
30	1	1	1	3	20:20:18	24.88	134.87	41.31	35.16	26.89	-11.03	-24.1	5.0	.06	0000000000000100
30	1	2	1	6	20:22: 8	24.77	135.12	37.59	40.52	117.49	-16.59	-30.6	4.0	.07	0000000000000100
31	1	1	1	4	20:20:11	25.11	135.42	22.19	39.74	27.03	-12.40	-26.8	3.6	.06	0000000000000100
31	1	2	1	7	20:22:15	24.96	135.44	28.77	43.40	117.67	-17.66	-31.6	4.0	.07	0000000000000100
32	1	2	1	8	20:22:23	25.15	135.75	55.68	46.04	117.83	-18.31	-31.9	4.4	.08	0000000000000100
32	1	2	1	9	20:22:31	25.35	136.04	89.00	48.39	118.01	-18.74	-31.7	5.1	.08	0000000000000100
32	1	1	1	5	20:20: 3	25.37	135.99	84.99	44.08	27.23	-12.97	-28.1	3.1	.07	0000000000000100
33	1	2	1	10	20:22:38	25.55	136.31	122.33	50.55	118.18	-18.20	-30.8	5.5	.00	0000000000000100
29	1	1	1	2	20:20:33	25.08	134.14	106.82	30.30	26.80	-8.88	-20.7	6.6	.07	0000000000000100
29	1	2	1	4	20:22: 8	25.26	134.06	116.15	33.83	117.12	-13.11	-26.0	5.1	.07	0000000000000100
29	1	2	1	5	20:22:15	25.43	134.41	87.55	37.33	117.29	-15.83	-29.3	4.5	.07	0000000000000100

Figure 3.- Listing of portion of single merged file of SASS in situ data.

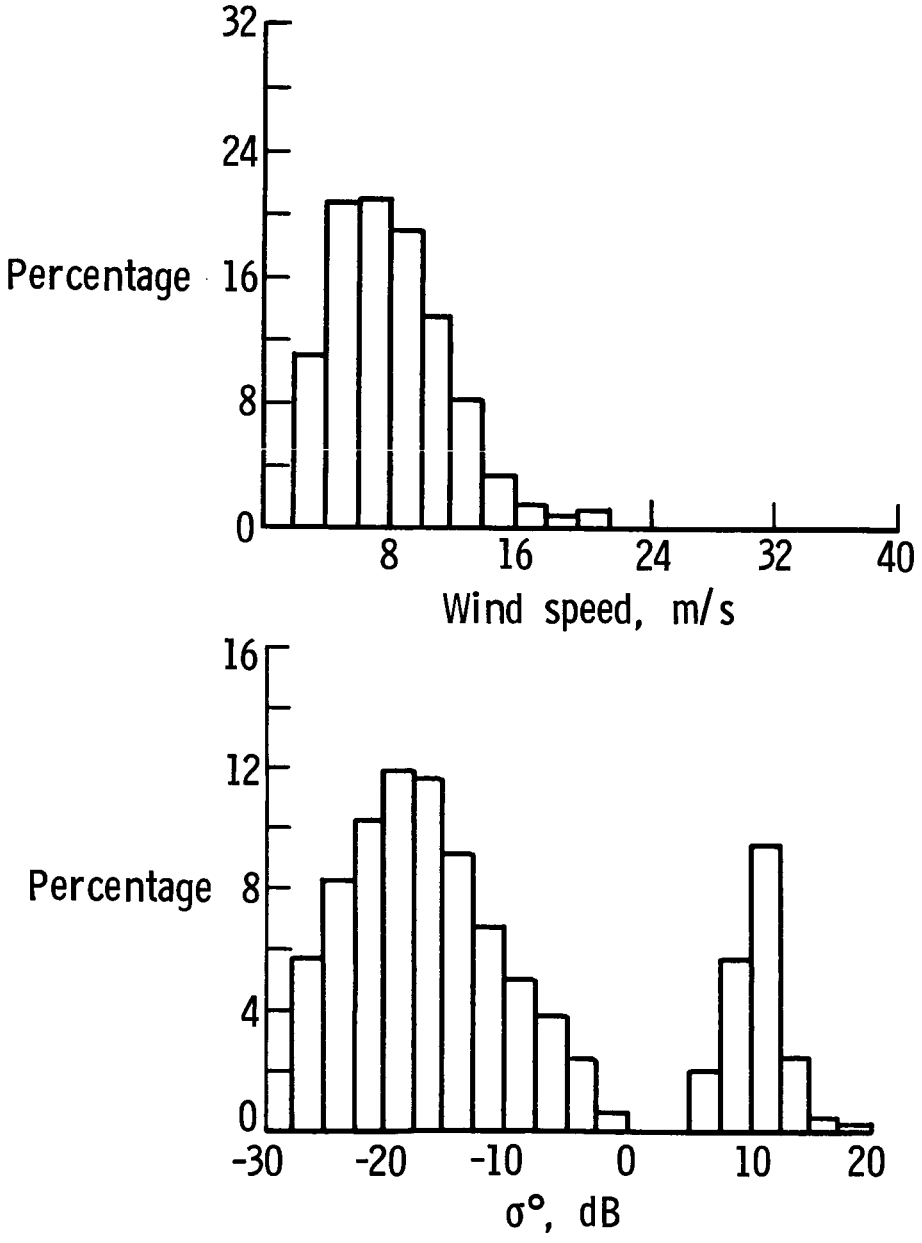


Figure 4.- Distribution of in situ wind speed and σ° for merged file containing vertical polarized SASS data.

APPENDIX

DOCUMENTATION AND PROGRAM TO READ AND DEFINE MERGED SURFACE-TRUTH/SASS DATA FILES

```
C!!!
C!!!    THIS TAPE-READ PROGRAM WAS WRITTEN BY JON SWEET AT NASA LARC.
C!!!    ANY QUESTIONS OR PROBLEMS CAN BE REFERRED TO:
C!!!
C!!!                LYLE SCHROEDER
C!!!                NASA LARC MS490
C!!!                HAMPTON, VA  23665
C!!!                PHONE: (804) 865-3631
C!!!                FTS: 928-3631
C!!!
C!!!    THIS PROGRAM READS THE TAPE OF MERGED SURFACE-TRUTH/SASS DATA
C!!!    CREATED AT NASA LARC AND PROVIDED TO NTIS.  IT ALSO WRITES OUT
C!!!    THE DATA IN A CONVENIENT, EASY-TO-READ FORMAT.
C!!!
C!!!    THE FOLLOWING IS A LIST OF THE PARAMETERS, THEIR UNITS OF
C!!!    MEASURE , AND THE MEANING OF EACH.
C!!!
C!!!    PARAMETER   UNITS                MEANING
C!!!    ------------------------------------------------------------
C!!!                      SITE HEADNOTE
C!!!    ------------------------------------------------------------
C!!!    SITE                             WEATHER STATION, SHIP, BUOY,
C!!!                                     RESEARCH TOWERS
C!!!    LAT          DEGREES             LATITUDE OF SITE (+ FOR NORTH,
C!!!                                     - FOR SOUTH)
C!!!    LON          DEGREES             EAST LONGITUDE OF SITE
C!!!    ANHT         METERS              ANEMOMETER HEIGHT
C!!!    AVTIM        MINUTES             INTEGRATION TIME OF MEASUREMENTS
C!!!
C!!!               SITE DATA AT TIME OF HIT
C>>>    THE PRESENCE OF -99'S INDICATES THE DATA WERE NOT AVAILABLE
C!!!    ------------------------------------------------------------
C!!!    IHIT         DAYS, HOURS,
C!!!                 MINUTES, SECONDS    TIME WHEN SASS NADIR POSITION IS
C!!!                                     DIRECTLY ABOVE OR ABREAST OF THE SITE
C!!!    WSP          METERS/SECOND       WIND SPEED AT SITE
C!!!    IWDR         DEGREES             WIND DIRECTION (OUT OF)
C!!!    DTEMP        DEGREES, C          AIR TEMPERATURE
C!!!    SEATEMP      DEGREES, C          SEA TEMPERATURE
C!!!    WTEMP        DEGREES, C          WET BULB TEMPERATURE
C!!!    DEW          DEGREES, C          DEW POINT TEMPERATURE
C!!!    PRESS        MILLIBARS           BAROMETRIC PRESSURE
C!!!    PRESW                            PRESENT WEATHER CODE
C!!!    PASTW                            PAST WEATHER CODE
C>>>                                     WEATHER CODES ARE FROM THE WEATHER
C>>>                                     SERVICE OBSERVING HANDBOOK NO. 1,
C>>>                                     U.S. DEPT. OF COMMERCE, NOAA, NWS
C!!!    WVHGT        METERS              WAVE HEIGHT
C!!!    WVDIR        DEGREES             WAVE DIRECTION (OUT OF)
C!!!    WVPER        SECONDS             WAVE PERIOD
C!!!    SWELHGT      METERS              SWELL HEIGHT
C!!!    SWELDIR      DEGREES             SWELL DIRECTION (OUT OF)
C!!!    SWELPER      SECONDS             SWELL PERIOD
C!!!    AUSTWVE                          AUSTRALIAN WAVE INFORMATION
C>>>                                     PUBLICATION B220 OF THE AUSTRALIAN
C>>>                                     BUREAU OF METEOROLOGY
```

```
C!!!    RAIN        MM/HOUR             AMOUNT OF RAINFALL SINCE LAST
C!!!                                    OBSERVATION
C!!!    IQUAL                           SURFACE-TRUTH QUALITY FLAGS
C>>>
C>>>                QUALITY FLAG INTERPRETATION
C>>>
C>>>    1.  NO WIND DIRECTION PRESENT
C>>>    2.  NO STABILITY CORRECTION MADE (AIR AND SEA TEMPERATURE MISSING)
C>>>    3.  ZERO STABILITY CORRECTION (AIR OR SEA TEMPERATURE MISSING)
C>>>    4.  RELATIVE HUMIDITY SET TO .75 (NO HUMIDITY INFORMATION)
C>>>    5.  ONLY ONE WSP MEASUREMENT (NO INTERPOLATION)
C>>>    6.  NO WSP MEASUREMENT < OR = 90 MINUTES FROM THE HIT
C>>>
C>>>     NOTES ON FLAGS 5 AND 6:
C>>>     EVERY EFFORT WAS MADE TO COLLECT SURFACE-TRUTH BOTH WITHIN 3 HOURS
C>>>    BEFORE AND 3 HOURS AFTER THE HIT.  OBVIOUSLY, IT WAS NOT ALWAYS
C>>>    POSSIBLE, SO INTERPOLATION WAS DONE TO COME UP WITH THE SURFACE
C>>>    TRUTH PRESENTED IN THIS TAPE IN THE FOLLOWING CASES:
C>>>    1.  BOTH WSP MEASUREMENTS < 90 MINUTES FROM THE HIT
C>>>    2.  ONE WSP MEASUREMENT WAS < 90 MINUTES, THE OTHER WAS > 90
C>>>        MINUTES BUT < 180 MINUTES FROM THE HIT
C>>>    3.  BOTH WSP MEASUREMENTS WERE > 90 MINUTES BUT < 180 MINUTES
C>>>        FROM THE HIT.  IN THIS CASE, FLAG SIX WAS SET
C>>>
C>>>    IN CASES WHERE ONLY ONE WSP WAS PRESENT (OR THERE WERE 2 WSP
C>>>    MEASUREMENTS BUT ONE WAS > 180 MINUTES AWAY), NO INTERPOLATION
C>>>    WAS DONE.  THE DATA FOR THE CLOSER MEASURE WERE TAKEN:
C>>>    1.  WSP < 90 MINUTES AWAY, FLAG 5
C>>>    2.  WSP > 90 MINUTES BUT <180 MINUTES AWAY, FLAGS 5 AND 6
C>>>
C!!!
C!!!                    SASS DATA
C>>>    FROM THE CANADIAN ORDERED SASS SENSOR TAPES,
C>>>    ATTN:  DR. STEVE PETEHERYCH, CANADIAN ATMOSPHERIC ENVIRONMENT SERVICE,
C>>>           ONTARIO, CANADA
C!!!    ------------------------------------------------------------
C!!!    I                                50KM BIN NUMBER
C!!!    MODE                             SASS MODE
C!!!    IBEAM                            BEAM NUMBER
C!!!    IPOL                             POLARIZATION (0 = HORIZONTAL,
C!!!                                     1 = VERTICAL)
C!!!    ICELL                            CELL NUMBER
C!!!    IOBHMS      HOURS, MINUTES,
C!!!                SECONDS              TIME OF SASS OBSERVATION
C!!!    OBLAT       DEGREES              GEODETIC LATITUDE FOR SASS OBS.
C!!!    OBLON       DEGREES              EAST LONGITUDE FOR SASS OBS.
C!!!    DIST*       KM                   DISTANCE OF CENTER OF CELL TO SITE
C!!!    OBTHET      DEGREES              INCIDENCE ANGLE FOR SASS OBS.
C!!!    OBAZ        DEGREES              AZIMUTH CLOCK ANGLE FOR SASS OBS.
C!!!    OBSIG       DB                   FINAL INSTR. + ATMOS. CORR. ABS.
C!!!                                     VALUE OF NRCS
C!!!    OBTSD       DB                   TOTAL STD. DEVIATION OF NRCS
C!!!    OBNSD*      %                    NORMALIZED STD. DEVIATION OF NRCS
C>>>                                     THE PRESENCE OF 999.9 MAY
C>>>                                     INDICATE THE VALUE IS GREATER
C>>>                                     THAN 999.9
C!!!    OBATT       DB                   NRCS ATTENUATION CORRECTION
C!!!    IBIT                             QUALITY FLAG FOR SASS OBS.
```

```
C>>>     * CALCULATED PARAMETERS
C!!!
         PROGRAM READTP
         DIMENSION IBIT(16), IOBHMS(3), IHIT(4), SITE(2), IQUAL(6)
         INTEGER SITE, AVTIM, PRESW, PASTW, WVDIR, SWELDIR, AUSTWVE
         REAL LAT, LON
C!!!
C!!!     READ THE SITE HEADNOTE
C!!!
         READ (10, 1000, END = 999) SITE, LAT, LON, ANHT, AVTIM
         WRITE (6, 1100) SITE, LAT, LON, ANHT, AVTIM
C!!!
C!!!     READ THE SITE DATA HEADNOTE
C!!!
    10   READ (10, 1200, END = 999) IHIT, WSP, IWDR, DTEMP, SEATEMP,
     &            WTEMP, DEW, PRESS, PRESW, PASTW
         READ (10, 1250, END=999) WVHGT, WVDIR, WVPER, SWELHGT, SWELDIR,
     &            SWELPER, AUSTWVE, RAIN, IQUAL
    20   WRITE (6, 1300) IHIT, WSP, IWDR, DTEMP, SEATEMP, WTEMP, DEW,
     &            PRESS, PRESW, PASTW, WVHGT, WVDIR, WVPER, SWELHGT,
     &            SWELDIR, SWELPER, AUSTWVE, RAIN, IQUAL
C!!!
C!!!     READ THE SASS DATA
C!!!
    30   READ (10, 1400, END = 999) I, MODE, IBEAM, IPOL, ICELL,
     &            IOBHMS, OBLAT, OBLON, DIST, OBTHET, OBAZ, OBSIG,
     &            OBTSD, OBNSD, OBATT, IBIT
C!!!
C!!!     THE SASS DATA TERMINATES WHEN ALL PARAMETERS CHANGE TO 9'S
C!!!     OR 99'S.  SINCE THERE ARE ONLY 4 BEAMS ON SEASAT, WHEN BEAM = 9,
C!!!     THIS INDICATES THE END OF THE SASS DATA AND TIME TO READ
C!!!     ANOTHER SITE DATA HEADNOTE.
C!!!
         IF (IBEAM .EQ. 9) THEN
            READ (10, 1200, END = 999) IHIT, WSP, IWDR, DTEMP,
     &               SEATEMP, WTEMP, DEW, PRESS, PRESW, PASTW
            READ (10, 1250, END = 999) WVHGT, WVDIR, WVPER, SWELHGT,
     &               SWELDIR, SWELPER, AUSTWVE, RAIN, IQUAL
            WRITE (6, 1500)
            GO TO 20
         ENDIF
         WRITE (6, 1600) I, MODE, IBEAM, IPOL, ICELL, IOBHMS, OBLAT,
     &            OBLON, DIST, OBTHET, OBAZ, OBSIG, OBTSD,
     &            OBNSD, OBATT, IBIT
         GO TO 30
   999   CONTINUE
         STOP
  1000   FORMAT (2A10, 2F5.1, F4.1, I3)
  1100   FORMAT ('1',///5X,2A10,3X,'LAT = ',F5.1,', LON = ',F5.1,
     &          ', ANEMOMETER HGHT = ',F4.1,'M, MEASUREMENTS AVGED OVER',
     &          I3,' MINS',//4X,'HIT TIME      WSP',14X,'TEMP DEG C',
     &          11X,'AIR     WEATHER',10X,'WAVE',14X,'SWELL',8X,
     &          'AUST    RAIN QUALITY',/2X,
     &          'DDD HH MM SS   19.5M WDR    AIR   ',
     &          'SEA   WET   DEW    PRESS  PRESENT PAST    HT  DIR   ',
     &          'PER     HT  DIR   PER WAVE INFO   MM  123456')
  1200   FORMAT (I3, 3I2, F5.1, I3, 4F5.1, F6.1, 2I3)
  1250   FORMAT (2(F5.1, I3, F5.1), I3, F5.1, 6I1)
```

```
1300  FORMAT (2X,I3,3(1H:,I2),F7.1,I5,1X,4F6.1,F9.1,I6,I7,F7.1,I5,
     &         F6.1,F7.1,I5,F6.1,I7,F9.1,1X,6I1,/2X,130('-'),/7X,'50K',
     &         102X,'QUALITY',/7X,'BIN MODE BEAM POL CELL   TIME      ',
     &         'LAT    LON     DIST   INCD    AZ',6X,'SIGZ   TSDDB   ',
     &         'NSD%',4X,'ATT',7X,'BITS')
1400  FORMAT (I2, 3I1, 4I2, 3F6.2, F5.2, 3F6.2, F5.1, F5.2, 16I1)
1500  FORMAT ('1',//4X,'HIT TIME      WSP',14X,'TEMP DEG C',
     &         11X,'AIR     WEATHER',10X,'WAVE',14X,'SWELL',8X,
     &         'AUST    RAIN QUALITY',/2X,
     &         'DDD HH MM SS   19.5M WDR    AIR   ',
     &         'SEA   WET   DEW    PRESS  PRESENT PAST    HT  DIR   ',
     &         'PER     HT  DIR   PER WAVE INFO   MM  123456')
1600  FORMAT (5X, I5, I4, I5, 3X, I1, I5, I4, 2(':', I2), 3F8.2,
     &         F7.2, 2F8.2, 2F7.1, F7.2, 2X, 16I1)
      END
```

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15. Supplementary Notes

Lyle C. Schroeder: Langley Research Center, Hampton, Virginia.
Jon L. Sweet: PRC Kentron, Inc., Hampton, Virginia.
Magnetic data tapes are available as a supplement to this report.

16. Abstract

A large data base of Seasat-A Satellite Scatterometer (SASS) measurements merged with high-quality surface-truth wind, wave, and temperature data has been documented. The data base was developed for all times when selected in situ measurement sites were within the SASS footprint. Data were obtained from 42 sites located in the coastal waters of North America, Australia, Western Europe, and Japan and were assembled by correlating the SASS and surface-truth measurements in both time and distance. These data have been archived on a set of nine-track 6250 bpi ASCII coded magnetic tapes, which are available from the National Technical Information Service.

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