DATA FORMATS

B. R. Miller

1. INTRODUCTION

The observational data formats described are the ones used by SAO in various computer programs.

The optical observation format is the same as that used in the past. It has been reproduced here to facilitate use by ISAGEX members.

The laser format has been revised to provide room for time designation to the nearest nanosecond and range to 0.01 m. Temperature is now given in degrees Celsius, pressure in millibars, and humidity in percent.

2. SAO OPTICAL OBSERVATION CARD FORMAT AND EXPLANATION

Field	Column	Description
1	1–7	Satellite identification
	1–2	year of launch from 1900
	3–5	number of launch in that year
	6–7	particle number
		Satellite 1959 α1, for example, would be designated 5900101.
2	8–12	Observation number – Each observation of a satellite in a given year is designated by a different number. The source of an observation is also indicated by the observation number.
		1-9999 miscellaneous
		10000-19999 Baker-Nunn, field-reduced
		30000-39999 Moonwatch
		50000-59999 miscellaneous
		70000-79999 photoreduced Baker-Nunn

Field	Column	Description
3	13	Blank
4	14–17	Station number – In the COSPAR numbering format, e.g., 9039 is Natal, Brazil.
5	18–23	Date of observation
	18–19	year, from 1900
	20–21	month
	22–23	day
6	24–33	Time designation – Different types of observations are made using different time systems. Different times used in reporting SAO observations are as follows: a. Field-reduced Baker-Nunn observations – generally WWV received before 1966, UTC(USNO) after. b. Photoreduced Baker-Nunn observations – A.S Note: A.S is a time scale with a fixed relation to NBS(A) before April 1968 and to A.1 after then. Values of (A.S-WWV emitted) are available in tabular form.
	24–25	hour
	26–27	minute
	28–29	second
	30–33	fraction of seconds, to 0.1 msec
7	34–52	The interpretation of the following field depends on the code in column 56. If column 56 is 0, then the observation is right ascension and declination (α, δ).
	34	blank
	35–36	hours of α
	37–38	minutes of α
	39–40	seconds of α
	41–43	fractions of seconds to 0.001 sec
	44	sign of δ
	45–46	degrees of δ
	47–48	minutes of δ
	49–50	seconds of δ

Field	Column	Description
	51–52	fractions of seconds to 0.01 sec
		If column 56 is 1, the observation is altitude and azimuth corrected for atmospheric refraction. Altitude and azimuth observations not corrected for atmospheric refraction have 3 in column 56.
	34–36	degrees of azimuth; 999 indicates azimuth is in mils
	37–38	minutes of azimuth
	39–40	seconds of azimuth
	41–43	fraction of seconds to 0.001 sec
	37–41	mils to nearest tenth if azimuth is in mils; decimal point assumed before column 41
	44	blank
	45–46	degrees of altitude; 999 indicates altitude is in mils
	47–48	minutes of altitude
	49–50	seconds of altitude
	51–52	fractions of seconds to 0.01 sec
	45–51	mils to nearest tenth if altitude is in mils; decimal assumed before column 51
		If column 56 is 4, the observation is direction cosines (ℓ, m), corrected for refraction; a 5 in column 56 indicates the observation is in direction cosines uncorrected for refraction.
	34	sign of ℓ (blank or minus)
	35–42	ℓ to 8 decimal places (decimal point implied before column 35)
	43	blank
	44	sign of m (blank or minus)
	45–52	m to 8 decimal places (decimal point implied before column 45)
		$n = \ell^2 + m^2$
8	53–58	Index codes
	53	time-precision index

Code	Standard error in timing σ_t
0	No estimate
1	$\sigma_t \leq 0.0003$ sec
2	$0.0003 < \sigma_t \leq 0.002$
3	$0.002 < \sigma_t \leq 0.005$

Field	Column	Description

Code	Standard error in timing σ_t
4	$0.005 < \sigma_t \leq 0.02$
5	$0.02 < \sigma_t \leq 0.05$
6	$0.05 < \sigma_t \leq 0.2$
7	$0.2 < \sigma_t \leq 0.5$
8	$0.5 < \sigma_t \leq 2.0$
9	$\sigma_t > 2.0$

54–55 position precision index

Code	Standard error in direction σ_D
00	No estimate
01	$\sigma_D \leq$ 1!!5
02	1!!5 $< \sigma_D \leq$ 2!!5
03	2!!5 $< \sigma_D \leq$ 3!!5
04	3!!5 $< \sigma_D \leq$ 4!!5
05	4!!5 $< \sigma_D \leq$ 5!!5
06	5!!5 $< \sigma_D \leq$ 6!!5
07	6!!5 $< \sigma_D \leq$ 7!!5
08	7!!5 $< \sigma_D \leq$ 8!!5
09	8!!5 $< \sigma_D \leq$ 9!!5
10	9!!5 $< \sigma_D \leq$ 10!!5
11	10!!5 $< \sigma_D \leq$ 11!!5
12	11!!5 $< \sigma_D \leq$ 12!!5
13	12!!5 $< \sigma_D \leq$ 13!!5
14	13!!5 $< \sigma_D \leq$ 14!!5
15	14!!5 $< \sigma_D \leq$ 15!!5
16	15!!5 $< \sigma_D \leq$ 16!!5
17	16!!5 $< \sigma_D \leq$ 17!!5
18	17!!5 $< \sigma_D \leq$ 18!!5
19	18!!5 $< \sigma_D \leq$ 19!!5
20	19!!5 $< \sigma_D \leq$ 20!!5
21	20!!5 $< \sigma_D \leq$ 22"
22	22" $< \sigma_D \leq$ 23!!5
23	23!!5 $< \sigma_D \leq$ 26"
24	26" $< \sigma_D \leq$ 29"
25	29" $< \sigma_D \leq$ 33"

Field	Column	Description

Code	Standard error in direction σ_D
26	$33'' < \sigma_D \leq 38''$
27	$38'' < \sigma_D \leq 45''$
28	$45'' < \sigma_D \leq 54''$
29	$54'' < \sigma_D \leq 1!1$
30	$1!1 < \sigma_D \leq 1!3$
31	$1!3 < \sigma_D \leq 1!7$
32	$1!7 < \sigma_D \leq 2!1$
33	$2!1 < \sigma_D \leq 2!7$
34	$2!7 < \sigma_D \leq 3!5$
35	$3!5 < \sigma_D \leq 4!4$
36	$4!4 < \sigma_D \leq 5!8$
37	$5!8 < \sigma_D \leq 7!5$
38	$7!5 < \sigma_D \leq 9!7$
39	$9!7 < \sigma_D \leq 13'$
40	$13' < \sigma_D \leq 17'$
41	$17' < \sigma_D \leq 22'$
42	$22' < \sigma_D \leq 28'$
43	$28' < \sigma_D \leq 37'$
44	$37' < \sigma_D \leq 49'$
45	$49' < \sigma_D \leq 1°1$
46	$1°1 < \sigma_D \leq 1°4$
47	$1°4 < \sigma_D \leq 1°8$
48	$1°8 < \sigma_D \leq 2°4$
49	$2°4 < \sigma_D$

56 observation type index

Code	Explanation
0	right ascension, declination
1	altitude, azimuth (corrected for refraction)
2	not used
3	altitude, azimuth (uncorrected for refraction)
4	ℓ, m (direction cosines, corrected for refraction)
5	ℓ, m (direction cosines, uncorrected for refraction)

Field	Column	Description
	57	This index refers to the date of equator and equinox to which the observation is referred. (Meaningful for right ascension and declination only.)

Index	Date
0	Date of observation
1	1855.0
2	1875.0
3	1900.0
4	1950.0

58 instrument description index

Code	Optical observations
0	naked eye and binoculars, visual
1	telescope, aperture less than 5 inches
2	apogee telescope, astronomical refractor or reflector, theodolite, visual
3	Baker-Nunn camera, photographic
4	small missile tele-camera, tracking cameras with focal length 20 inches or greater, photographic
5	cinetheodolite, tracking cameras with focal length less than 20 inches, photographic
6	Harvard meteor camera (Super-Schmidt), photographic
7	stationary telescope or camera with focal length equal to or less than 10 inches, photographic
8	direction observation associated with a laser instrument
9	other instruments

9	59–64	Blank
10	65–70	Conversion from the UT1 to the A.1 time system, i.e., A.1 - UT1
	65	minus if A.1 - UT1 is negative, or tens digit if positive and necessary

Field	Column	Description
	66	units digit of A. 1 - UT1 in seconds
	67–70	decimal fraction A. 1 - UT1
11	71–80	Identification information
	71–75	film number
	76	contains an S if observation is simultaneous
12	77–78	Passive or flash information a. If the satellite is a flashing one, column 77 will contain an F and column 78 will contain the number of the flash as it actually occurred. (This does not apply to ANNA flashes.) b. If the satellite is passive, columns 77 and 78 will contain the frame number.
13	79	Contains the letter associated with the film number if any; otherwise it will be blank.
14	80	Used for balloon satellites to indicate a precision reduction correction for satellite size has been added; otherwise blank.
11	71–80	Moonwatch – used for apparent magnitude information.

Precisely reduced Baker-Nunn observations are given in the coordinate system of the SAO Star Catalog (equator and equinox of 1950.0). The positions have been corrected for annual aberration, and the star positions, for proper motion to the year of observation. No corrections have been applied for diurnal aberration or parallactic refraction.

The time of the observation is given in A.S (Smithsonian Atomic Time), defined by the expression

$$A.S - UTC(USNO) = 6^{S}.140768 + 0.002592000\ (T - 39856.0)$$

for the time period February 1, 1968, to the present; T is the Universal Time in Modified Julian Days (MJD), and 39856 is January 1, 1968:

MJD = Julian Day - 2400000.5 .

3. SAO LASER OBSERVATION FORMATS AND EXPLANATION

Field	Column	Description
1	1–7	Satellite identification
	1–2	year of launch from 1900
	3–5	number of launch in that year
	6–7	particle number
		Satellite 1964 64A, for example, would be designated 6406401
2	8–12	Observation number
		20000-29999 uncorrected observation
		70000-79999 corrected observation
		90000-99999 GOCC laser and direction observation
3	13	Blank
4	14–17	Station number – In the COSPAR numbering format, e.g., 7921 is SAO laser site at Mt. Hopkins, Arizona. Station designations in the 7000 series include laser sites.
5	18–23	Date of observation
	18–19	year from 1900
	20–21	month
	22–23	day
6	24–35	Time designation – Different types of observations are made using different time systems. Time systems used are indicated by the code in column 57.
	24–25	hour
	26–27	minute
	28–29	second
	30–35	fraction of seconds to 1 μsec
7	36–52	Interpretation of the following field depends on the codes in columns 56 and 57.
	36	blank

Field	Column	Description
	37–46	range in meters (decimal implied before column 45 allows range observations to be specified to 0.01 m)
	47–48	blank
	49–52	value of refractivity correction to 0.01 m – code 1 in column 57
8	53–58	Index codes
	53	time precision index

Code	Standard error in timing σ_t
0	$\sigma_t \leq 0.000005$ sec
1	$\sigma_t \leq 0.0003$ sec

	54–55	standard deviation of the range σ_r in meters and tenths of meters
	56	observation type index

Code	Explanation
1	altitude, azimuth on laser instrument
8	laser range

	57	code to indicate time system and corrections applied

Code	Explanation
0	UTC emitted at transmission of laser pulse – no corrections applied to range
1	A.S time at reception of laser pulse – refractivity correction given in columns 49–52 but not applied to range
2	A.S time at reception of laser pulse – refractivity correction applied to range
3	UTC time at the satellite (GOCC observations – refractivity correction applied to range)

	58	Instrument description index

Code	Explanation
8	Laser observation

9	59–64	Range correction – pulse shape and size – codes 0 and 1 in column 57
	59	sign
	60	meters

Field	Column	Description
	61	10 centimeters
	62	centimeters
	63–64	blank
11	65–77	Pressure, humidity, temperature – uncorrected observations only, code 0 in column 57
	65–66	blank
	67–70	barometric pressure in millibars
	71–72	humidity in percent
	73	sign of temperature
	74–76	temperature to tenths of degrees Celsius
	77	blank
	65–77	Conversion from the UT1 to the A.1 time system i.e., A.1 - UT1 (actually A.S), code 2 in column 57
	65	minus if A.S - UT1 is negative, or tens digit if positive and necessary
	66	units digit of A.S - UT1 in seconds
	67–72	decimal fraction of A.S - UT1
	74–77	blank
12	78–80	Identification information
	78	blank
	79	type of laser pass
	80	blank

Code	Explanation
0	night pass, satellite illuminated
1	night pass, satellite in shadow
2	daylight pass