

CHAPTER I

OPERATIONAL PROCEDURES

A. GENERAL

Operational procedures involve the use of analysis and forecast aids, in the preparation sequence prior to issuing the warning. Within the Fleet Weather Central/Joint Typhoon Warning Center (FWC/JTWC), the basic analysis is the responsibility of the Fleet Weather Central (FWC). Micro-analysis, forecast aid evaluation and the warnings as described below are the functions of the Joint Typhoon Warning Center (JTWC).

B. ANALYSIS - FWC/JTWC

1. Types of contour and/or streamline charts with standard times:

- a. Surface, 0000Z, 0600Z, 1200Z and 1800Z.
- b. Gradient level (2000 to 3000 ft above ground) 0000Z and 1200Z.
- c. 850mb, 0000Z and 1200Z.
- d. 700mb, 0000Z and 1200Z.
- e. 500mb, 0000Z and 1200Z.
- f. 300mb, 0000Z and 1200Z.
- g. 200mb, 0000Z and 1200Z.

2. Cross Sections:

- a. Checkerboards or Stidd Diagram.
- b. Time Cross Sections analyzed for θ_e .
- c. Space Cross Sections.

3. Micro-Analysis:

- a. Sectional charts, hourly and 3-hourly as required.
- b. Reconnaissance reports.

4. Easterly Wave Continuity Graph.

C. FORECAST AIDS

These are listed in alphabetical order and priority of importance is not indicated.

1. Climatology

Upon detection of a tropical cyclone and in preparation for issuance of the initial warning, a track based on climatology is developed. This track is prepared for a time interval of 4 or 5 days at the speed indicated by climatology. The following climatological publications are utilized when constructing the original forecast track for each cyclone:

- a. Climatological Aid to Forecasting Typhoon Movement (1st Weather Wing)
- b. Western Pacific Typhoon Tracks 1950-1959 (FWC/JTWC)
- c. Far East Climatic Atlas (1st Weather Wing - February 1963)
- d. Tropical Cyclones in the Western Pacific and China Sea Area (Royal Observatory, Hong Kong). This comprehensive publication covers 78 years of typhoon tracks.

Next, the track is modified in accordance with the existing and forecast upper air pattern, after which the initial warning is prepared and issued. The forecast track is extended and modified with time, as reconnaissance fixes are received and the synoptic upper air pattern changes.

2. Computer Products

During the 1963 Typhoon Season the following computer products were received and used extensively by JTWC:

- a. From FNWF Monterey
 - (1) Steering Computations, or forecast positions, for 6, 12, 18, 24, 36, 48 and 72 hours for TD's, TS's and Typhoons (as requested by JTWC). These computations are prepared at 0000Z, 0600Z, 1200Z and 1800Z daily.
 - (2) 700mb, 500mb, 300mb and 200mb height and wind analysis
 - (3) 700mb, 500mb, 300mb and 200mb 24-hour prog
 - (4) 700mb, 500mb, 300mb and 200mb 36-hour prog
 - (5) 48-hour 500mb height and wind prog

- (6) 72-hour 500mb height and wind prog.
- (7) 500mb Long Wave Analysis and 48-hour prog.

All of the Monterey products are based on a Barotropic model. Items (2) and (7) are received twice daily for the synoptic times 0000Z and 1200Z.

b. From NMC Suitland

- (1) 12-hour 500mb height, wind and vorticity prog.
- (2) 24-hour 500mb height, wind and vorticity prog.
- (3) 36-hour 500mb height, wind and vorticity prog.
- (4) 48-hour 500mb height and wind prog.
- (5) 72-hour 500mb height and wind prog.
- (6) NWP Barotropic prog positions for typhoons for 12, 24, 36, 48, 60 and 72 hours.

All NMC items are received twice daily for the synoptic times 0000Z and 1200Z. All items are based on a Barotropic Model with the exception of items (4) and (5) which are based on a Baroclinic Model.

c. JTWC utilized computer steering computations, computer prognostic constant pressure charts and synoptic analyses as the main tools for forecasting typhoon movement during the 1963 season. (See Chapter II for an explanation and evaluation of techniques).

3. Coordination

Routine coordination with other U. S. agencies is obtained prior to issuance of a warning. When a circulation for which warnings are being issued is north of 25N, Fuchu Air Force Weather Central transmits coordination forecasts twice daily to JTWC. Coordination with other Air Force and Navy activities is on an "as required" basis, depending upon the location of a particular tropical cyclone.

4. Statistical Methods

The Miller-Moore and the Arakawa methods were used by JTWC early in the 1963 season, but as computer products became more numerous, these statistical methods were eliminated because of limited time and personnel.

5. Surveillance Systems

See Chapter II for evaluations of aerial reconnaissance, land radar and satellites.

6. Seay Graph

A hydrostatic graph was computed to check the eye data pressure reports from reconnaissance aircraft penetration. It was found that quite often the transmitted sea level pressure (SLP) was in error in excess of 10mb.

The graph for finding maximum surface winds was based on seven years of reconnaissance data. The data, 1956 through 1962, was used to modify the equation of Captain Limon E. Fortner, Jr. (1956), Typhoon Sara, Bulletin of the American Meteorological Society, Vol. 39, pp. 633-639.

$$\text{The equation, } V_{\max} = (19 - \frac{\theta}{5}) \sqrt{372 - \frac{H7(\text{ft})}{28}}$$

was obtained from a best fit basis.

Where: V_{\max} = maximum surface winds
 θ = latitude of cyclone
 $H7$ = minimum 700mb height

$$\text{The equation, } V_{\max} = -100 + \sqrt{500V_7}$$

Where: V_{\max} = maximum surface wind within the cyclone
 V_7 = maximum 700mb wind at penetration

for converting maximum 700mb wind at penetration to maximum surface winds within the cyclone was derived from the seven years of data. The equation is not defined when the 700mb wind is less than 20 kts.

A straight line correlation between the 700mb height and the SLP does not always exist. The temperature at the 700mb level can vary with the same 700mb height and this varies the SLP. To correlate the maximum surface wind with the minimum SLP, the temperature at the 700mb level (Tropical Storm 14°C, Typhoon 17°C, Super Typhoon 22°C) must be used for accuracy.

7. Work Chart

This is an operational and recording tool used in preparing tropical cyclone warnings. The basic chart is one of the Pacific Air Ways Plotting Chart series, plus 3 acetate overlays. All aircraft and land radar fixes are plotted on the basic chart. Twenty-four hour forecast positions are plotted on the bottom overlay, warning positions are plotted on the second overlay and the top overlay is utilized as a worksheet. Green, red and black china marking pencils are used on the three acetates for instantaneous visual reference.

8. Decay Graph

The decay of typhoon winds over land for Japan, Korea and Taiwan was developed from four years of data (1959-1962) based on best tracks prepared by JTWC. The following equation was used to fit the best track data to a family of curves:

$$V = C_1 \prod_{n=1}^{\infty} \left[V_n \left(e^{-C_2 V_n \bar{Z}} + e^{-C_3 t} + e^{-C_4 \frac{\sin \phi}{r} \frac{\partial P}{\partial t}} \right) \right]$$

Where:

V = Maximum wind speed in meters/second at any given time period

\bar{Z} = Mean altitude of land mass above sea-level in meters

t = Time in seconds using a time period for each calculation of three hours and t=0 when wall cloud strikes land

ϕ = Latitude of land strike

r = Radius of curvature of storm in meters measured from storm center to last closed isobar.

$\overline{\frac{\partial P}{\partial t}}$ = Mean central pressure change with time such that at $t=0$, $\frac{\partial P}{\partial t} = 0$. $C_1 = .33$, $C_2 = C_3 = 10^{-5}$, $C_4 = 5 \times 10^8$

D. WARNINGS

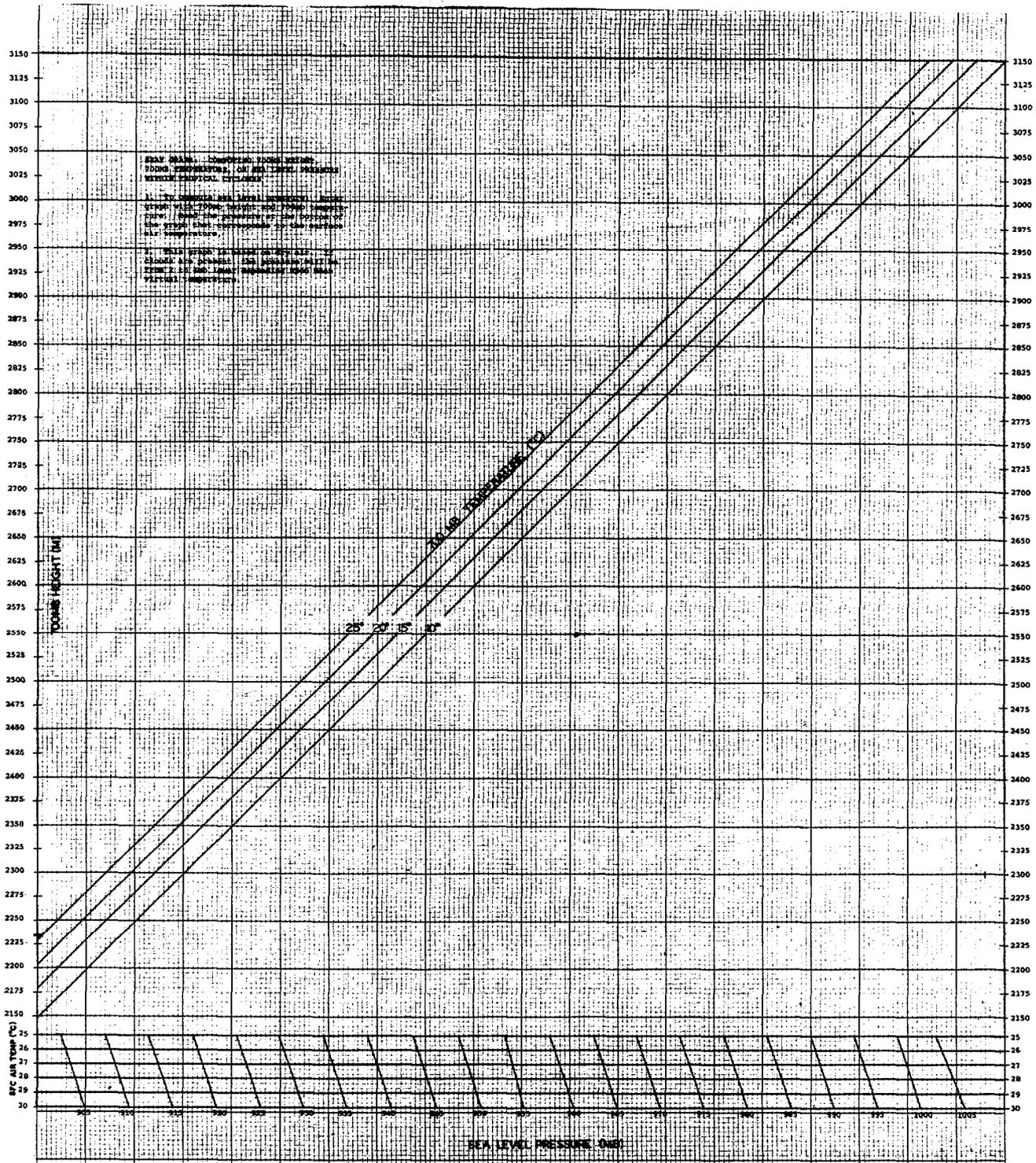
Warnings are filed and transmitted every six hours at synoptic times of 0000Z, 0600Z, 1200Z, and 1800Z. In accordance with CINCPAC INST 3140.1E, the message contains the present warning position of the tropical cyclone which is valid for the scheduled transmission time. This connotes that the 24 and 48 hour warning forecast positions are actually 30 and 54 hour forecasts from the last synoptic time.

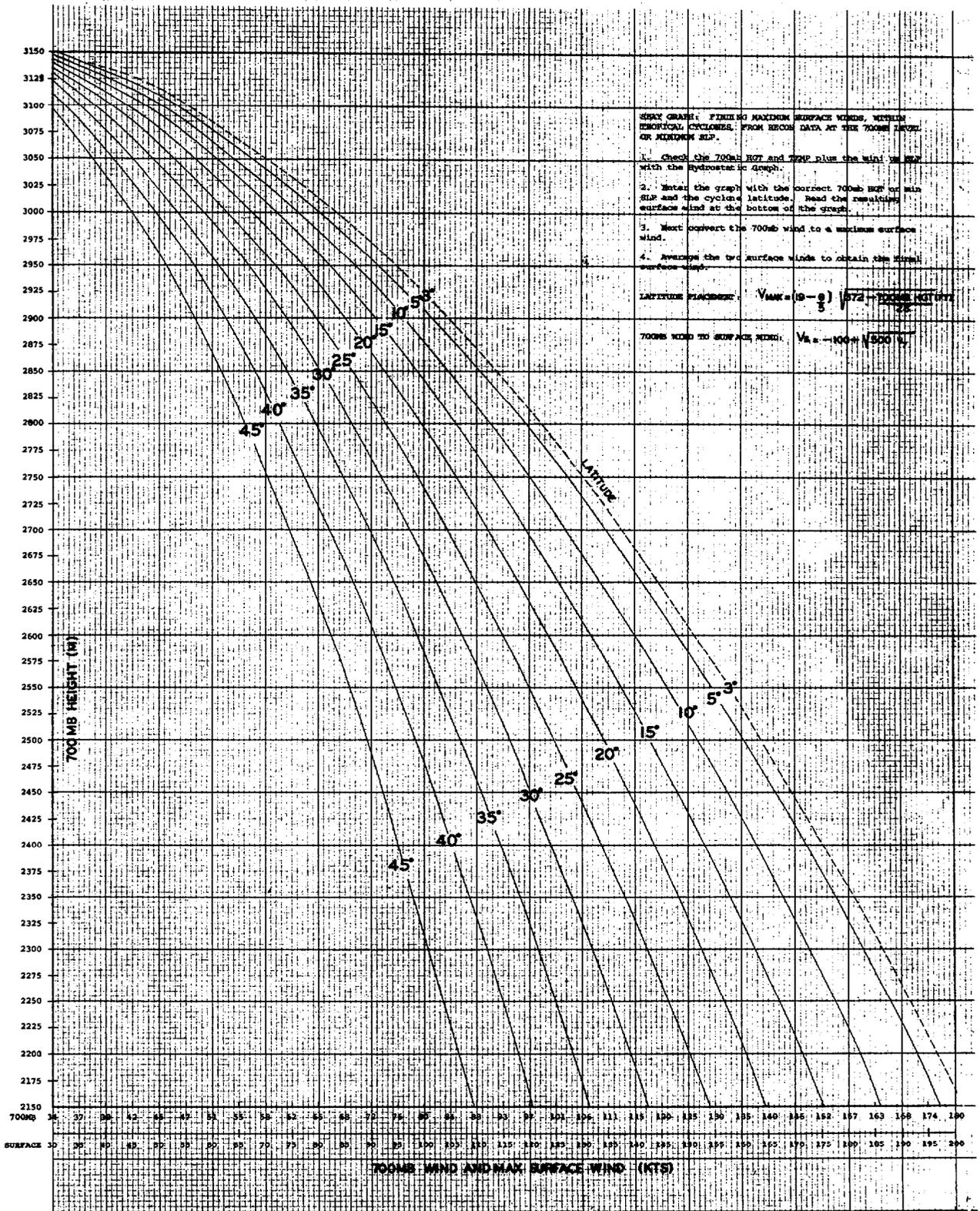
The warning position of a tropical cyclone is actually a short range forecast from the last "best" position. The last "best" position is usually about 2 hours old based on land radar, 2 to 3 hours old based on reconnaissance fixes, 3 to 6 hours old based on surface synoptic reports or 6 to 12 hours old based on upper-air synoptic reports. It is for this reason that the 0600Z warning, for example, may not agree with the position of the tropical cyclone as indicated by the 0600Z analysis. Amendments are issued when this difference is significant.

The numbers of tropical warnings run consecutively regardless of whether the cyclone is upgraded or downgraded from tropical depression, tropical storm or typhoon. If warnings are discontinued and the circulation regenerates, the new series of warnings are numbered consecutively from the number of the last warning of the previous series. As required, amendments and corrections are issued, and these are numbered the same as the warning which they amend or correct.

The 1963 Verification Summary is contained in Chapter III.

All 24, 48 and 72-hour forecasts made when a tropical cyclone is of tropical storm or typhoon intensity are verified against the "best" tracks at all latitudes through the last warning issued.





$$V = C_1 \left[\sum_{n=1}^{\infty} V_n \left(\frac{-C_2 V_n Z}{e} - \frac{C_3 t}{e} - \frac{C_4 \sin \phi}{r} \frac{\partial P}{\partial t} \right) \right]$$

Where:

V = Maximum wind speed in meters/second at any given time period

Z = Mean altitude of land mass above sea-level in meters

t = Time in seconds using a time period for each calculation of three hours and $t=0$ when wall cloud strikes land

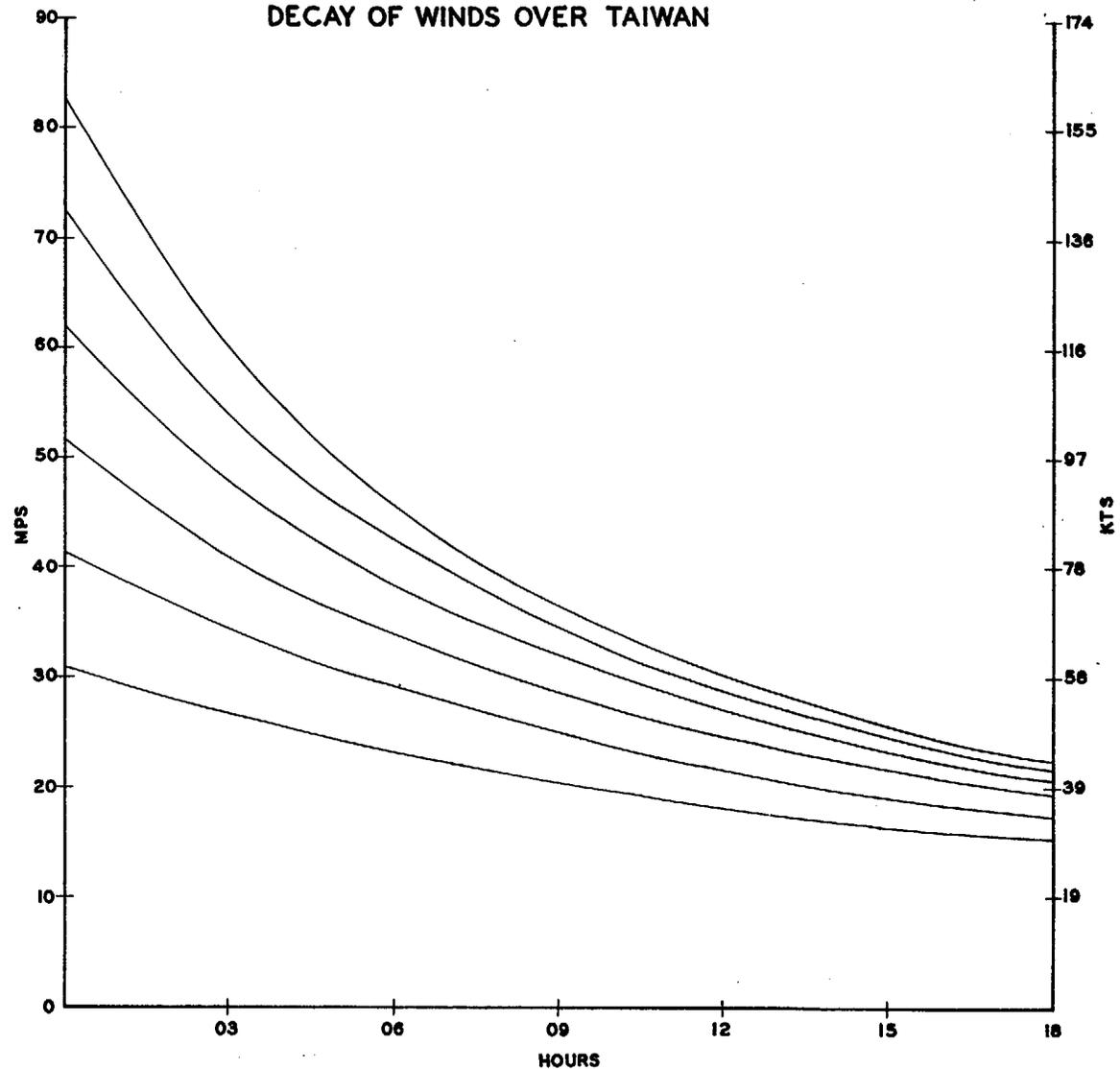
ϕ = Latitude of land strike

r = Radius of curvature of storm in meters measured from storm center to last closed isobar

$\frac{\partial P}{\partial t}$ = Mean central pressure change with time such that at $t=0$, $\frac{\partial P}{\partial t} = 0$. $C_1 = .33$,

$$C_2 = C_3 = 10^{-5}, \quad C_4 = 5 \times 10^8$$

DECAY OF WINDS OVER TAIWAN



$$V = C_1 \left[\sum_{n=1}^{\infty} V_n \left(e^{-C_2 V_n \bar{Z}} + e^{-C_3 t} + e^{-C_4 \frac{\sin \phi}{r} \frac{\partial P}{\partial t}} \right) \right]$$

Where:

V = Maximum wind speed in meters/second at any given time period

\bar{Z} = Mean altitude of land mass above sea-level in meters

t = Time in seconds using a time period for each calculation of three hours and t=0 when wall cloud strikes land

ϕ = Latitude of land strike

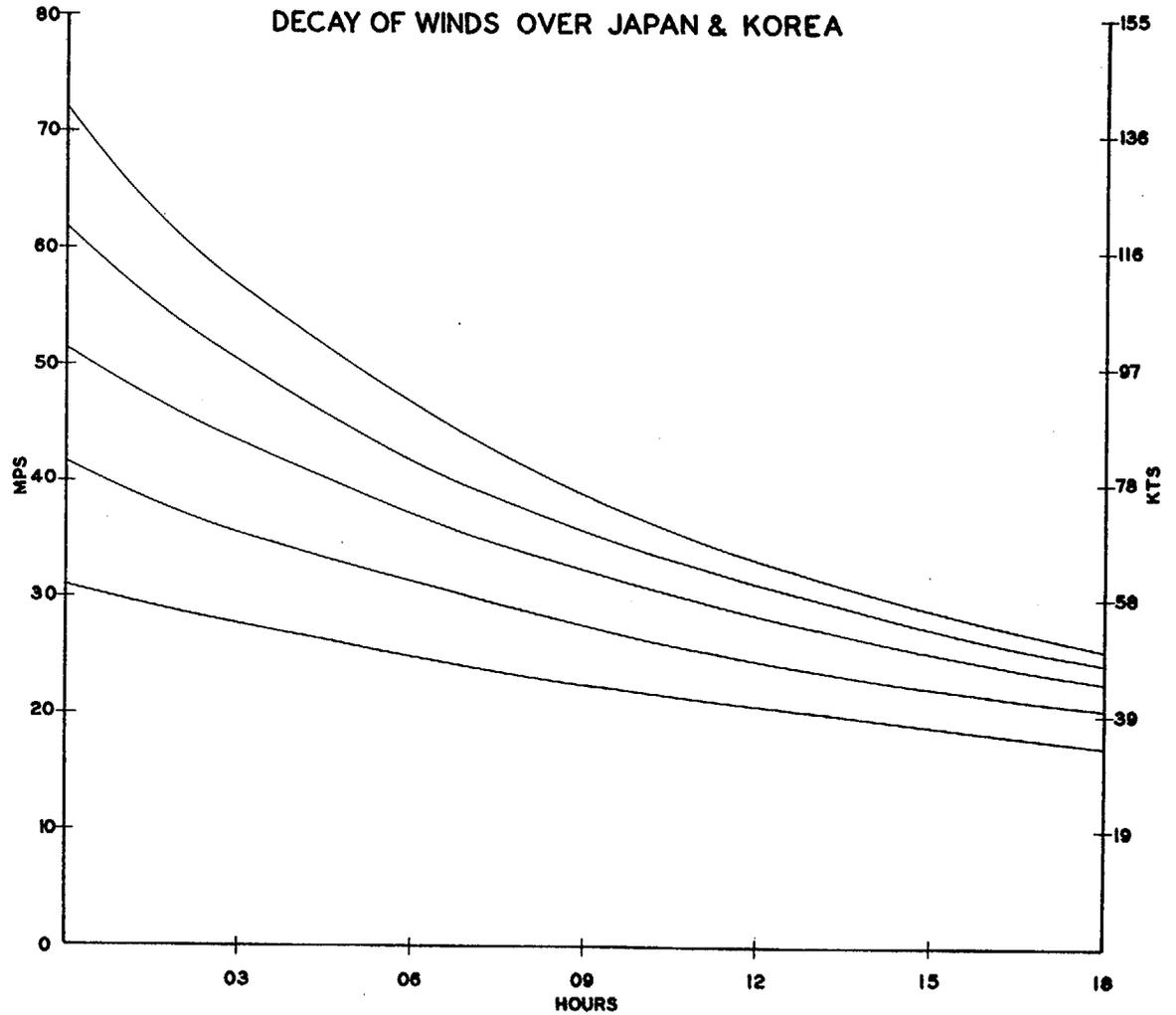
r = Radius of curvature of storm in meters measured from storm center to last closed isobar

$\frac{\partial P}{\partial t}$ = Mean central pressure change with time such that at t=0, $\frac{\partial P}{\partial t} = 0$. $C_1 = .33$,

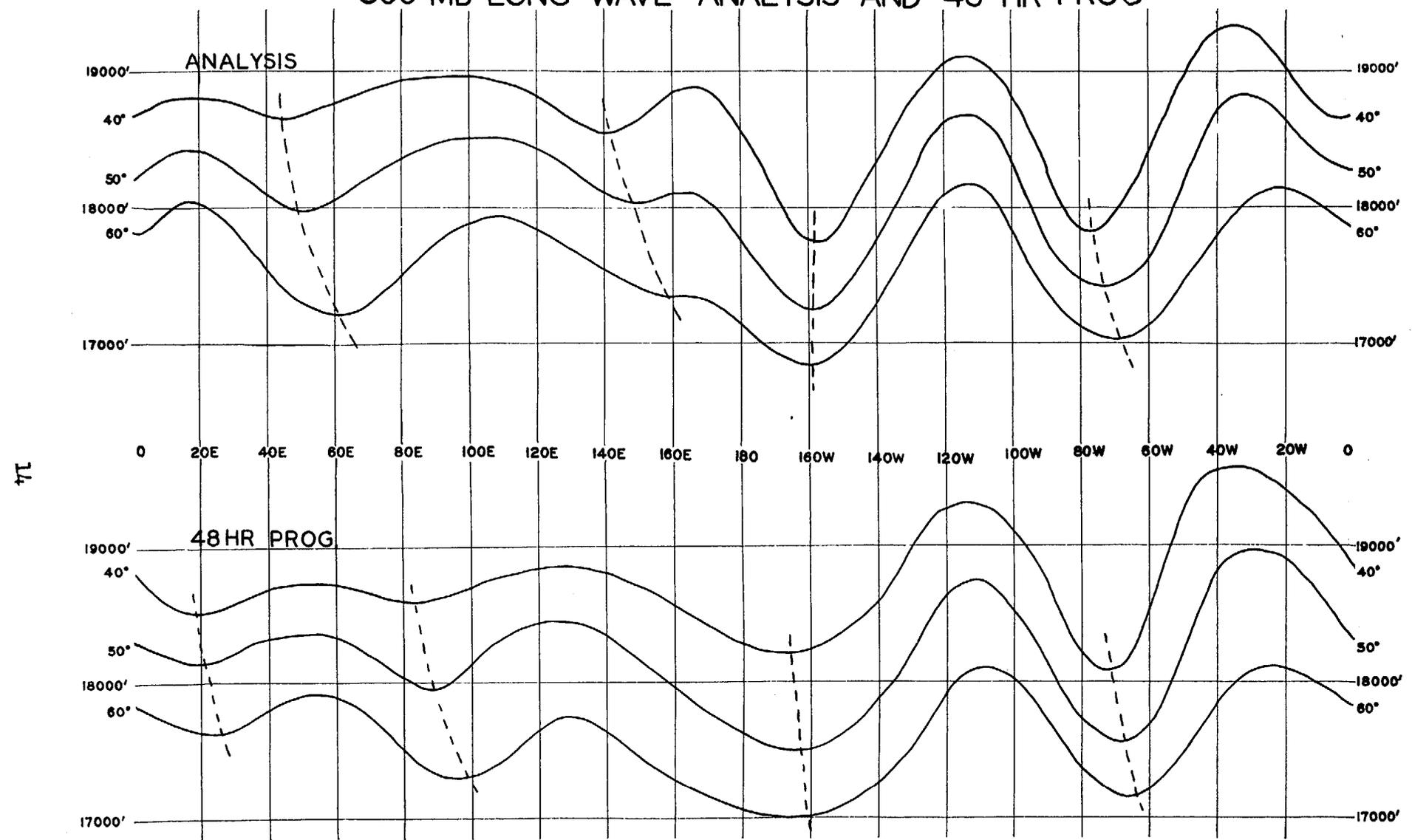
$$C_2 = C_3 = 10^{-5}, \quad C_4 = 5 \times 10^8$$

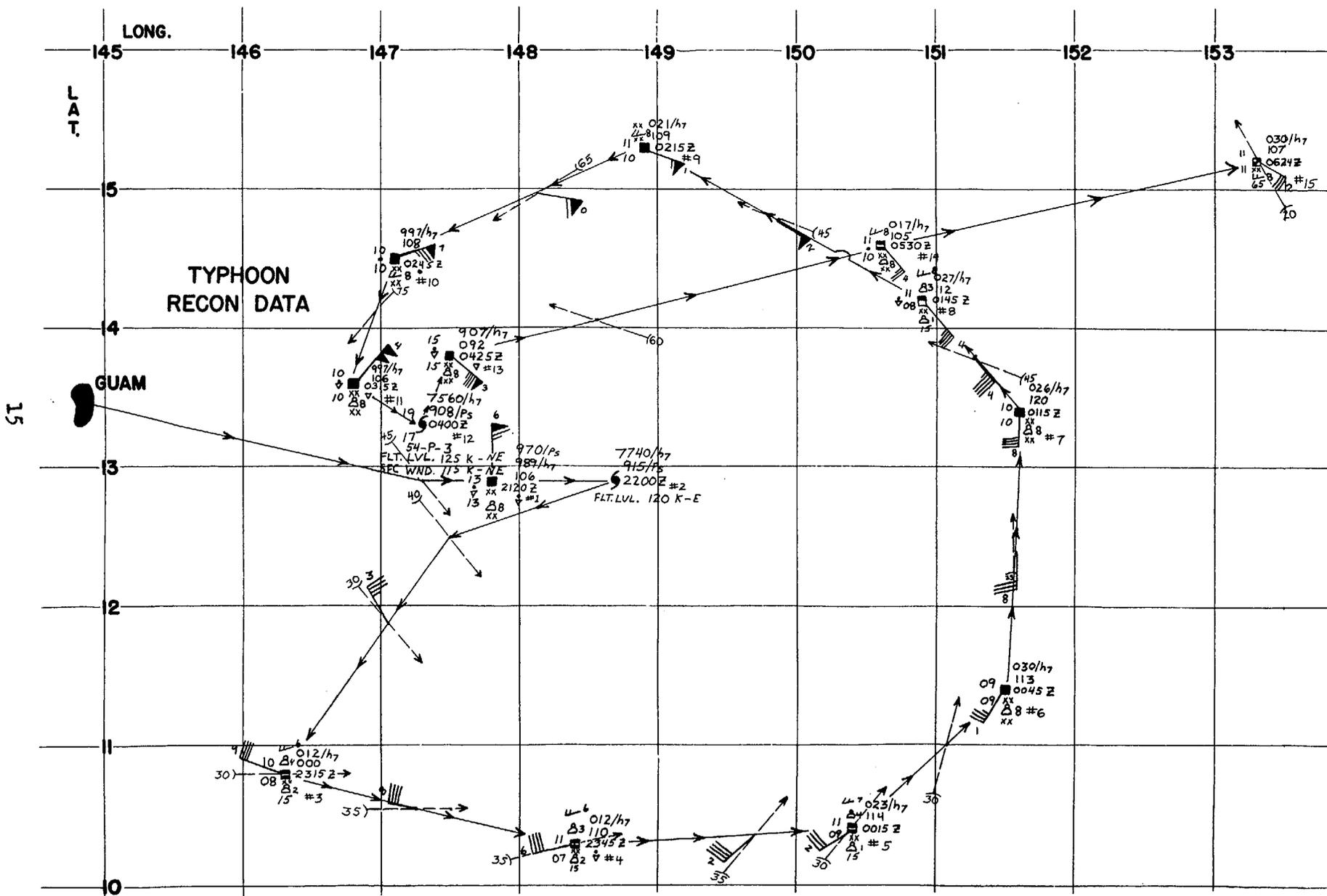
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DECAY OF WINDS OVER JAPAN & KOREA



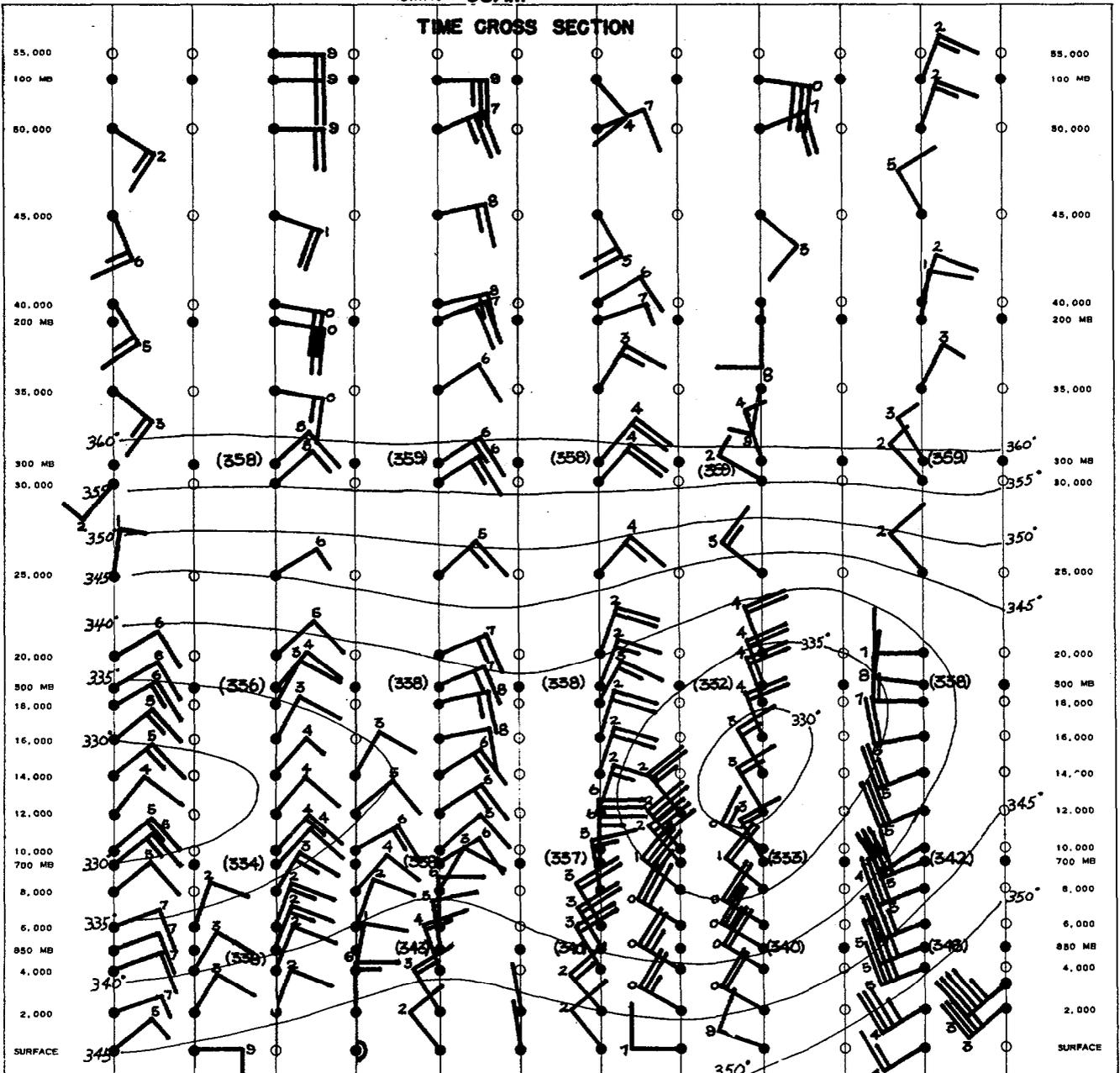
500 MB LONG WAVE ANALYSIS AND 48 HR PROG



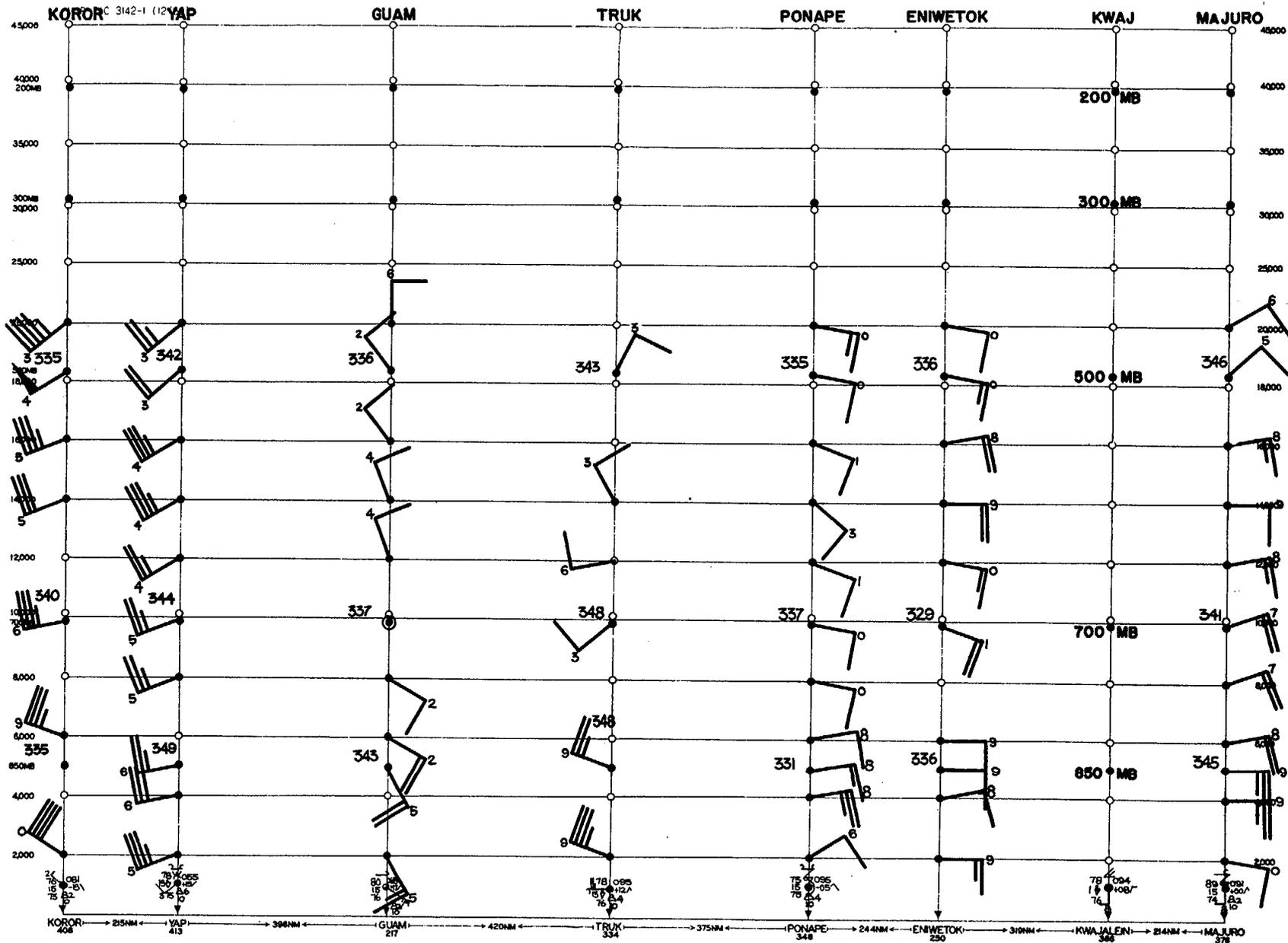


STATION: GUAM

TIME CROSS SECTION



TIME SFC DATA	00Z	03Z	06Z	09Z	12Z	15Z	18Z	21Z	00Z	03Z	06Z	09Z	12Z	15Z	18Z	21Z	00Z	03Z	06Z	09Z	12Z	15Z	18Z	21Z	TIME SFC DATA
Ch	→	→	→	→	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	Ch
Cm					ω	ω	ω	ω	ω	ω	ω	ω	ω	ω	ω	ω	ω	ω	ω	ω	ω	ω	ω	ω	Cm
CL	☉	☉	☉	☉	☉	☉	☉	☉	☉	☉	☉	☉	☉	☉	☉	☉	☉	☉	☉	☉	☉	☉	☉	☉	CL
N	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	N
W									▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	W
ww	×	×		×	(•)	••			×	×	×	×	×	×	×	×	×	(•)	×	×	×	×	×	••	ww
PPP	1010.5	1010.1	1008.9	1008.4	1010.4	1009.8	1008.0	1008.0	1008.9	1007.7	1006.0	1006.5	1007.0	1005.7	1004.4	1004.8	1005.8	1004.3	1003.7	1004.7	1006.9	1005.7	1004.9	1006.2	PPP
app	+0.3	-0.2	-0.8	+0.5	+1.0	-0.7	-1.9	+2.1	-0.2	-1.2	-1.7	+0.5	+0.5	-1.9	-1.4	+0.5	+0.7	-1.2	-0.7	+1.0	+1.2	-0.2	-0.8	+1.4	app
RR														.61	.24						.41				RR
24 HR Δ P	-0.2	-0.2	-0.5	-0.6	-0.6	-0.2	-1.9	MISG	-1.6	-2.8	-2.9	-2.9	-3.4	-4.3	-3.6	-4.2	-	-2.4	-2.3	-	-1.1	±0.0	+0.5	+0.4	24 HR Δ P
Δ P																									Δ P



SPACE CROSS SECTION (KOROR-MAJURO)

SCALE: 1" = 110NM
FWC/GTWC DEC 1960

TIME

STIDD DIAGRAM

DATE	KOROR	YAP	GUAM	TRUK	PONAPE	ENI-WETOK	KWAJ.	MAJURO
08/2100Z	80 122 15 02 76 10 -2	81 087 15 07 76 10 +3	78 090 15 07 76 10 +9	81 058 15 02 76 10 -3	77 055 13 00 76 10 -5	84 081 15 02 77 10 +10	81 104 15 01 72 10 +5	78 110 15 00 72 10 +2
09/0000Z	85 102 15 20 76 10 +10	85 208 15 04 77 10 +5	85 084 15 06 77 10 +10	83 058 12 00 77 10 -5	85 061 15 06 76 10 -6	84 081 15 00 77 10 +10	84 107 15 03 73 10 +8	81 105 15 05 73 10 +3
09/0300Z	85 091 15 11 77 10 -5	85 086 15 10 78 10 -8	84 065 15 19 76 10 -11	75 067 15 11 74 10 -11	84 058 15 03 74 10 +4	86 068 15 13 74 10 +7	83 102 15 05 74 10 +4	81 100 15 05 74 10 +2
09/0600Z	86 207 15 20 76 10 -8	86 205 15 31 78 10 -12	87 057 15 08 76 10 -11	80 024 15 23 74 10 -20	76 054 15 04 75 10 +23	84 068 15 00 76 10 +10	81 098 15 04 76 10 +10	82 088 15 12 81 10 +5
09/0900Z	82 075 15 04 75 10 -12	84 205 15 01 76 10 -17	88 048 15 11 74 10 -13	80 027 15 03 73 10 -20	80 067 15 10 73 10 +20	83 088 15 03 75 10 +14	81 104 15 04 74 10 +17	81 090 15 02 76 10 +8
09/1200Z	86 089 15 14 76 10 -16	83 076 15 22 78 10 -23	89 074 15 06 76 10 -21	81 037 15 10 74 10 -25	75 081 15 17 74 10 +23	77 088 15 00 76 10 +19	79 110 15 04 73 10 +8	79 098 15 08 74 10 +11
09/1500Z	86 091 15 02 76 10 -21	80 074 15 02 76 10 -28	80 059 15 15 76 10 -30	75 032 15 05 74 10 -30	74 081 15 00 74 10 +37	80 088 15 00 76 10 +18	77 102 15 06 73 10 +12	82 102 15 04 74 10 +13
09/1800Z	84 080 15 11 76 10 -28	80 062 15 12 76 10 -32	80 071 15 17 75 10 -33	76 020 15 12 74 10 -33	74 070 15 11 74 10 +31	80 085 15 03 76 10 +21	77 098 15 04 74 10 +16	81 104 15 02 75 10 +4
09/2100Z	82 091 15 11 72 10 -31	79 055 15 07 78 10 -37	76 041 15 01 75 10 -49	78 025 15 04 74 10 -33	76 085 15 15 75 10 +30	82 102 15 17 74 10 +21	77 112 15 11 73 10 +8	82 115 15 11 73 10 +5
10/0000Z	80 091 15 00 75 10 -11	84 067 15 12 78 10 -29	83 051 15 05 80 10 -33	79 041 15 12 76 10 -17	83 088 15 03 75 10 +27	85 105 15 03 78 10 +14	78 115 15 03 73 10 +8	86 109 15 06 77 10 +4
10/0300Z	83 075 15 16 70 10 -16	82 055 15 12 79 10 -31	86 021 15 30 77 10 -44	85 037 15 04 79 10 -10	86 071 15 17 71 10 +13	87 091 15 14 76 10 +23	83 110 15 05 74 10 +8	84 105 15 04 73 10 +5
10/0600Z	86 051 15 24 78 10 -20	85 030 15 25 79 10 -25	75 023 15 02 75 10 -34	81 036 15 01 76 10 +12	84 064 15 07 75 10 +10	86 091 15 00 76 10 +23	84 102 15 08 74 10 +4	83 098 15 07 75 10 +10
10/0900Z	79 058 15 07 75 10 -17	81 033 15 03 78 10 -21	76 049 15 39 76 10 -49	82 051 15 15 75 10 +21	77 085 15 21 74 10 +21	85 104 15 13 77 10 +16	82 100 15 02 74 10 -4	83 085 15 13 74 10 -5
10/1200Z	80 071 15 13 76 10 -18	82 043 15 10 78 10 -23	77 049 15 04 76 10 -24	76 078 15 13 74 10 +17	75 098 15 13 74 10 +17	82 112 15 08 74 10 +24	82 098 15 02 75 10 -12	82 083 15 02 73 10 -15
10/1500Z	80 064 15 07 76 10 -22	82 030 15 13 77 10 -24	80 061 15 29 74 10 -28	77 064 15 14 75 10 +32	75 091 15 07 74 10 +10	77 095 15 17 74 10 +7	81 092 15 00 74 10 -10	91 085 15 02 73 10 -17
10/1800Z	82 044 15 20 76 10 -36	82 016 15 14 75 10 -46	78 045 15 16 75 10 -47	76 045 15 10 73 10 +24	76 078 15 13 74 10 +8	81 095 15 00 75 10 +10	81 092 15 08 75 10 -10	81 098 15 07 74 10 -12
10/2100Z	76 051 15 07 73 10 -14	78 008 15 08 76 10 -27	78 057 15 12 77 10 -28	82 071 15 17 75 10 +6	76 091 15 13 75 10 +6	79 105 15 10 74 10 +3	82 095 15 07 76 10 -17	84 090 15 02 75 10 -5
11/0000Z	81 064 15 13 75 10 -27	84 016 15 08 78 10 -21	78 062 15 05 77 10 +18	86 078 15 07 76 10 +17	77 105 15 14 74 10 +17	79 109 15 03 74 10 +3	86 107 15 02 76 10 -18	85 093 15 06 74 10 -16
11/0300Z	74 064 15 00 72 10 -11	78 015 15 01 76 10 -20	78 070 15 08 76 10 -21	85 067 15 11 76 10 +20	82 088 15 17 75 10 +17	87 105 15 03 75 10 +14	85 100 15 03 75 10 -10	86 096 15 03 76 10 -9
11/0600Z	76 041 15 23 73 10 -10	76 096 15 19 75 10 -34	81 075 15 05 74 10 -48	84 064 15 03 77 10 +28	81 085 15 03 73 10 +21	86 102 15 03 76 10 +11	85 098 15 02 74 10 -4	74 091 15 01 73 10 -3
11/0900Z	79 047 15 06 76 10 -11	74 015 15 19 73 10 -18	78 099 15 24 77 10 -20	82 081 15 17 74 10 +20	82 100 15 15 74 10 +15	81 104 15 02 74 10 -20	84 105 15 03 74 10 -5	83 085 15 10 72 10 -20
11/1200Z	75 069 15 22 74 10 -2	76 030 15 15 75 10 -13	77 108 15 33 77 10 +17	77 108 15 21 75 10 +30	76 108 15 08 75 10 +10	81 112 15 08 74 10 +0	82 103 15 03 75 10 -20	82 088 15 02 75 10 +5
11/1500Z	79 075 15 06 76 10 +11	79 016 15 14 75 10 -14	77 032 15 00 75 10 +7	77 097 15 11 75 10 +34	76 098 15 10 74 10 +7	81 108 15 09 74 10 +13	83 100 15 02 76 10 +8	82 092 15 04 74 10 +7
11/1800Z	75 068 15 07 74 10 +14	80 097 15 19 75 10 -19	78 035 15 03 77 10 -9	79 095 15 02 76 10 +11	76 095 15 03 75 10 +17	82 105 15 03 76 10 +10	81 102 15 02 75 10 +14	80 098 15 06 73 10 +6
11/2100Z	75 065 15 03 69 10 +14	80 015 15 18 77 10 +7	80 048 15 13 77 10 +9	79 108 15 13 74 10 +37	81 105 15 10 76 10 +14	84 108 15 03 76 10 +3	82 103 15 04 76 10 +8	85 100 15 02 74 10 +10
12/0000Z	81 069 15 04 74 10 +5	82 032 15 17 75 10 +16	86 075 15 27 81 10 +13	77 115 15 07 76 10 +37	85 108 15 03 75 10 +23	85 110 15 02 75 10 +22	83 104 15 03 76 10 +9	87 109 15 03 76 10 +10
12/0300Z	84 071 15 02 74 10 +7	84 033 15 01 75 10 +18	80 079 15 04 76 10 +10	80 102 15 13 74 10 +25	85 108 15 23 76 10 -3	88 102 15 03 77 10 -3	81 112 15 06 76 10 +12	87 108 15 05 74 10 +8
12/0600Z	78 070 15 01 74 10 +29	84 020 15 13 75 10 +24	77 078 15 10 74 10 +03	84 088 15 14 76 10 +24	84 075 15 10 76 10 -10	86 100 15 02 76 10 -2	82 113 15 01 77 10 +15	84 110 15 06 75 10 +15

GRADIENT WIND CHART

