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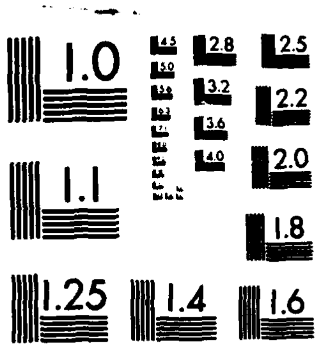

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geocentric tide data at all SST grid points, which are stored on three magnetic tapes (SST GTD Tapes I, II, and III). From the prepared SST GTD tapes, the third (STT) program computes instantaneous tides along parallel satellite tracks by a smooth and fast interpolation scheme. All three programs eliminate various input-error possibilities of their preliminary versions, which have been applied to compute instantaneous geocentric tides along SEASAT tracks. The program descriptions include corresponding User's Guides and Program Listings. An extended version of the STT program is in preparation. It will include group beat effects on all major tidal components by frequency-wise neighboring minor tidal modes.

FOREWORD

In this report, the authors describe an efficient computer program to compute geocentric tides along satellite tracks from prepared harmonic tidal constants computed on a standard satellite track grid system. The program is an improved version of a preliminary program, which has been applied to compute instantaneous geocentric tides along SEASAT tracks.

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Released by

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Strategic Systems Department

*National Ocean Survey (NOS)
National Oceanographic and Atmospheric Administration (NOAA)

CONTENTS

ABSTRACT

In the following report, the authors present three computer programs to compute geocentric tides including ocean and earth tides and ocean-loading effects along "parallel" satellite tracks from the harmonic ocean tidal constants listed on the NSWC GOTD Tape (Schwiderski and Szeto 1981). The first program prepares a basic standard satellite track (SST), which is shifted parallel to itself to define a $1^\circ \times 1^\circ$ SST grid system. The second program computes harmonic geocentric tide data at all SST grid points, which are stored on three magnetic tapes (SST GTD Tapes I, II, and III). From the prepared SST GTD tapes, the third (STT) program computes instantaneous tides along parallel satellite tracks by a smooth and fast interpolation scheme. All three programs eliminate various input-error possibilities of their preliminary versions, which have been applied to compute instantaneous geocentric tides along SEASAT tracks. The program descriptions include corresponding User's Guides and Program Listings. An extended version of the STT program is in preparation. It will include group beat effects on all major tidal components by frequency-wise neighboring minor tidal modes.

1. INTRODUCTION

In an earlier report, the authors (Schwiderski and Szeto 1981) described briefly the major features of the NSWC ocean tide models (Schwiderski 1978a, b, 1979a - e, 1980, 1981a - k, 1982a - d), which require indispensable consideration in various applications. In particular, suggestions were discussed to improve the model accuracy especially in coastal waters. These general discussions were followed by a detailed description of the arrangement and format of the NSWC Global Ocean Tide Data (GOTD) Tape (Schwiderski 1981k), which contains the 1° x 1° gridded harmonic ocean tide constants, i.e., amplitudes and phases.

Using the NSWC GOTD 1981 tape, a Random-Point Tide (RPTIDE) program was elaborated complete with User's Guide and Program Listing. The RPTIDE program computes oceanic and/or geocentric (including earth tides and loading effects) tides at randomly specified geographical points and instances. Since the required GOTD 1981 tape contains over one million data, the general RPTIDE program is cost-wise limited to a relatively small number of random points. It is definitely far too expensive and time consuming to compute, for instance, geocentric tidal heights along satellite tracks, which carry altimeters to measure the instantaneous sea surface height underneath the satellite every half second or so.

It is the purpose of the present report to present the special NSWC Satellite Track Tide (STT) program, which computes efficently geocentric tidal heights along tracks of altimeter-carrying satellites at the instances sea-surface measurements are being taken. It makes effective use of the fact that the ground tracks of satellites with identical and fixed-orbit parameters are essentially "parallel" to each other (see Figure 2). Indeed, disregarding negligible deviations, two consecutive satellite orbit tracks are congruent to each other in space and time, they differ only in a uniform longitudinal westward shift.

In Section 2, one finds a detailed description of the NSWC SST program and grid system, which generates from an approximately given standard satellite orbital ground track, a (basic) SST upon which the basic SST grid system is defined. Section 3 presents, in detail, the NSWC Standard Satellite Track Geocentric Tide Data (SST GTD) program, which converts the NSWC Global Ocean Tide Data (GOTD 1981) from its 1° x 1° spherical grid to the new SST grid system defined in Section 2. The generated new geocentric tide data are stored on three magnetic tapes (NSWC SST GTD Tapes I, II, and III) described in Section 4. These tapes are used in the NSWC STT program described in Section 5, which computes instantaneous geocentric tides along specified congruent satellite tracks. Finally, the Appendixes A, B, and C contain the corresponding User's Guides and Program Listings of all three NSWC programs (SST, SST GTD, and STT programs).

2. NSWC STANDARD SATELLITE TRACK (SST) PROGRAM AND GRID SYSTEM

The NSWC SST program generates from a given approximate standard satellite ground track between two consecutive ascending nodal points a basic SST, which serves as the basis of the SST grid system defined below.

Definition of ESST and ASST

An "exact" standard satellite track (ESST) is defined as a nonequatorial one-revolution ground track of a satellite (say, SEASAT or GEOS-3) traveling westward around the earth between two consecutive ascending nodal points both "exactly" on the equator. If one or both nodal points deviate slightly off the equator, the track is called "approximate" standard satellite track (ASST).

A. Input Data (ASST)

An ASST is specified by:

(1) (λ_j, ϕ_j) = longitudes (East, $0° \leq \lambda_j \leq 360°$) and latitudes (North, $-88° \leq \phi_j \leq +88°$) of $j = 1, 2, 3, \ldots, 381$ ASST points, which are uniformly spaced by the constant travel time $\Delta\tau = \hat{\tau}/380$, where

(2) $\hat{\tau}$ = orbital period (in sec)

The input data (1) and (2) ***must*** satisfy the following ASST accuracy conditions.

(a) The λ_j, ϕ_j, $\hat{\tau}$ values ***must*** be given to $0.5 \cdot 10^{-3}$ degrees and seconds, respectively.

(b) The exact ESST condition

$$\phi_1 = \phi_{381} = 0 \tag{1}$$

is in practical applications usually not fulfilled. However, the ***minimum*** approximate condition

$$|\phi_1| < 0.5° \text{ and } |\phi_{381}| < 0.5° \tag{2}$$

can and ***must*** be enforced to avoid significant losses in accuracy. The SST program checks this condition (see B. below) and rejects the given ASST in case of its violation.

Note 1: The Pole regions are excluded ($|\phi_i| \leq 88°$) to avoid, singularities in the grid system. The 381 spacing points along the ASST have been chosen to make the geographical distance between two consecutive points about equal to a one-degree equatorial distance. Of course, any other number of points could be chosen in principle.

B. Main Computation:

The following procedure generates from the given ASST an ESST, which is needed for the largest-integer arithmetic in the STT program of Section 5. This procedure simply shifts all track points along the corresponding parabolic tangents, in order to enforce Equation (1) while maintaining a constant but slightly adjusted travel time between the new consecutive track points (see Figure 1). At the same time the program shifts the resulting ESST to the Equator-Greenwich-Meridian intersection and augments the track by one skew-symetric additional point at each end. This completes the desired generation of the (basic) SST upon which the definition of the SST grid system is based (see Figure 2). The added two points simplify the practical application of the STT program of Section 5.

(1) Check for

$$|\phi_1| < 0.5 \text{ and } |\phi_{381}| < 0.5$$

if violated, reject given ASST, otherwise compute:

$$\Delta\tau = \hat{\tau}/380$$
$$\Delta\lambda_1 = \lambda_1 - \lambda_2 \ (+360 \text{ if} < 0)$$
$$\Delta\phi_1 = \phi_2 - \phi_1$$
$$\Delta\lambda_{381} = \lambda_{380} - \lambda_{381} \ (+360 \text{ if} < 0)$$
$$\Delta\phi_{381} = \phi_{381} - \phi_{380}$$
$$\Delta\tau_1 = \Delta\tau\phi_1/\Delta\phi_1$$
$$\Delta\tau_{381} = \Delta\tau\phi_{381}/\Delta\phi_{381}$$
$$\hat{\tau}' = \hat{\tau} - (\Delta\tau_{381} - \Delta\tau_1)$$
$$\widetilde{\Delta\tau} = (\Delta\tau_{381} - \Delta\tau_1)/_{380}$$
$$V = \frac{1}{\Delta\tau}\left[(\Delta\lambda_1)^2 + (\Delta\phi_1)^2\right]^{1/2}$$
$$\lambda = 360 - \lambda_1 - \phi_1\Delta\lambda_1/\Delta\phi_1)$$
$$\lambda'_{382} = \left[\lambda + \lambda_{381} + \phi_{381}\Delta\lambda_{381}/\Delta\phi_{381}\right] \text{ mod } 360, \ (0 \leqslant \lambda' \leqslant 360)$$

(2) For j = 2, 3, ... , 380 compute consectively:

$$\Delta\tau_j = \Delta\tau_{j-1} + \Delta\widetilde{\tau}, \ (\Delta\tau_1 \text{ see above})$$
$$\Delta\lambda_j = \lambda_{j-1} - \lambda_{j+1} \ (+360 \text{ if} < 0)$$
$$\Delta\phi_j = \phi_{j+1} - \phi_{j-1}$$

$$S_j = V\Delta\tau_j/[(\Delta\lambda_j)^2 + (\Delta\phi_j)^2]^{1/2}$$
$$\lambda'_{j+1} = (\lambda_j + S_j\,\Delta\lambda_j + \lambda) \mod 360, (0 \leqslant \lambda' \leqslant 360)$$
$$\phi'_{j+1} = \phi_j - S_j\,\Delta\phi_j$$

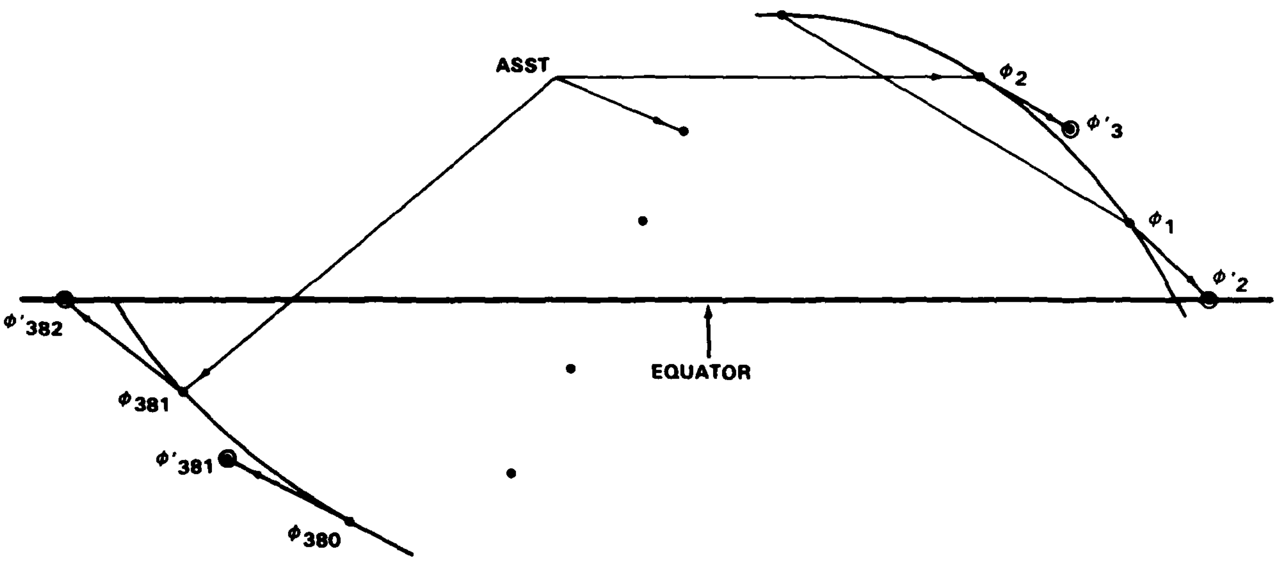

Figure 1. Construction of ESST from ASST

• Approximate SST points

⦿ Exact points

(3) Now generate the (basic) SST

$$\lambda_1 = 360 - \lambda'_3, \phi_1 = -\phi'_3$$
$$\lambda_2 = 360, \phi_2 = 0$$
$$\lambda_j = \lambda'_j, \phi_j = \phi'_j \quad (j = 3, 4, \ldots, 381)$$
$$\lambda_{382} = \lambda'_{382}, \phi_{382} = 0$$
$$\lambda_{383} = 2\lambda'_{382} - \lambda'_{381}, \phi_{383} = -\phi'_{381},$$
$$\hat{\lambda} = 720 - \lambda_{382},$$

and

$$\Delta\tau = \hat{\tau}'/380$$

(4) Print all SST points (λ_j, ϕ_j) $j = 1,2, \ldots, 383$, $\hat{\lambda}$, and $\Delta\tau$ on the SST G Tape I as described in Section 4.

Note 2: The User's Guide and Program Listing are given in Appendix A.

Definition of 1° x 1° SST Grid System

A 1° x 1° SST grid system of the earth is defined by shifting the basic SST (see (3) above) one-degree-wise westward "parallel" to itself as shown in Figure 2. Accordingly, the grid points are defined by:

$$\left.\begin{array}{l} \lambda_{jk} = \lambda_j + 1 - k \ (+\ 360 \text{ if } < 0) \\ \phi_{jk} = \phi_j \end{array}\right\} \begin{array}{l} j = 1,2, \ldots, 383 \\ k = 1,2, \ldots, 360 \end{array}$$

Note 3: As can be seen in Figure 2, the SST grid system is not a unique coordinate system. Indeed, through every given point in the SST range, one finds two crossing SST (ordinate) lines and in the overlapping region around the equator even three. Nevertheless, since only points on shifted SSTs will be considered in the STT program of Section 5, a unique geographical orientation is possible with the help of the travel time $\Delta\tau$ between grid points on the SST.

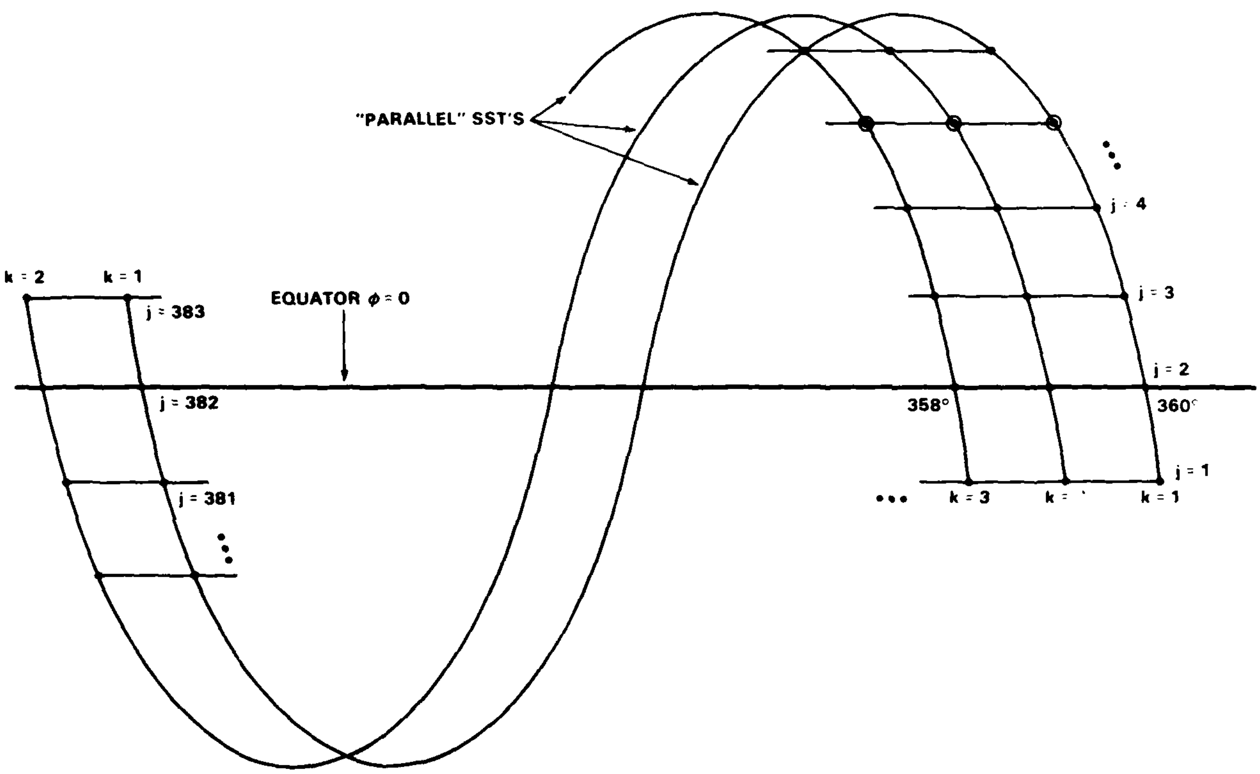

Figure 2. 1° x 1° SST Grid Scheme

◉ "Parallel" Points

3. NSWC STANDARD SATELLITE TRACK GEOCENTRIC TIDE DATA (SST GTD) PROGRAM

The NSWC (SST GTD) program interpolates at all SST grid points (Section 2) amplitudes and phases of any desired partial ocean tide by second-order ruled surfaces (linear in both east and north directions) using the NSWC GOTD tape described in Schwiderski and Szeto (1981). The interpolated values are modified by harmonic addition of the corresponding amplitudes and phases of the earth tide and of the earth dip in response to the ocean tidal load. These modifications are used in the form of simple Love and Accad-Pekeris approximations as explained in Schwiderski and Szeto (1981). Hence, the generated new harmonic constants on the $1^\circ \times 1^\circ$ SST grid system constitute amplitudes and phases of the total geocentric partial tide.

Note 1: No special effort is made to improve the accuracy of the oceanic tides in coastal waters. If higher accuracies are desired in such areas, instantaneous tidal computations should apply local refinements as suggested in Schwiderski (1981j) and Schwiderski and Szeto (1981).

A. Input Data

(1) (λ_j, ϕ_j) = *longitudes* (East, $0^\circ \leq \lambda_j \leq 360^\circ$) *and latitudes* (North, $-89^\circ < \phi_j < +89^\circ$) of j = 1, 2, 3 ..., 383 SST points generated by the SST program of Section 2 and printed, e.g., on the NSWC SST GTD Tape I described in Section 4 (Pole regions excluded !).

(2) $(\xi^i_{m,n}, \delta^i_{m,n})$ = ocean tide amplitudes (in m) and Greenwich phases (in deg) from GOTD 1981 tape, where m = 1,2, ..., 360 (longitude numbers) n = 1,2, ..., 168 (latitude number), and

(3) i = specified mode number $1 \leq i \leq 11$.

Note 2: $\xi^i_{m,n} = 9.999$, $\delta^i_{m,n} = 999.9$ on land

$\delta^i_{m,n} = 360^\circ = 0^\circ$ (phase jump)

(4) Earth tide parameters in GOTD Mode Order (see Schwiderski and Szeto 1981):

M_2	:	$i = 1,$	$\nu_1 = 2,$	$E_1 = 0.148\ 308$
S_2	:	$i = 2,$	$\nu_2 = 2,$	$E_2 = 0.069\ 059$
K_1	:	$i = 3,$	$\nu_3 = 1,$	$E_3 = 0.086\ 638$
O_1	:	$i = 4,$	$\nu_4 = 1,$	$E_4 = 0.061\ 551$
N_2	:	$i = 5,$	$\nu_5 = 2,$	$E_5 = 0.028\ 396$
P_1	:	$i = 6,$	$\nu_6 = 1,$	$E_6 = 0.028\ 668$
K_2	:	$i = 7,$	$\nu_7 = 2,$	$E_7 = 0.018\ 791$
Q_1	:	$i = 8,$	$\nu_8 = 1,$	$E_8 = 0.011\ 785$
Mf	:	$i = 9,$	$\nu_9 = 0,$	$E_9 = 0.025\ 546$
Mm	:	$i = 10,$	$\nu_{10} = 0,$	$E_{10} = 0.013\ 480$
Ssa	:	$i = 11,$	$\nu_{11} = 0,$	$E_{11} = 0.011\ 901$

B. Main Computation

(1) Transfer to core memory

(λ_j, ϕ_j) for $j = 1, 2, 3 \ldots 383$

Set $j = 1$ and $k = 1$

(2) Compute

$$\bar{\lambda}_j = (\lambda_j + 1.5 - k) \bmod 360, \ (0 \leq \bar{\lambda} \leq 360)$$

$$m = \text{Int}\,[\bar{\lambda}_j] + 1,$$

$$\psi = m - \bar{\lambda}_j$$

$$n = \text{Int}\,[90.5 - \phi_j] + 1,$$

$$\theta = \bar{\theta} = n - (90.5 - \phi_j)$$

If $n > 169$ (Antarctica!), set

$$\xi^i_{j,k} = \delta^i_{j,k} = 0$$

and go to (3) below.

If $n \not> 169$, transfer to core memory

$$(\xi^i_{m-1,\,n-1}, \delta^i_{m-1,\,n-1}); (\xi^i_{m,\,n-1}, \delta^i_{m,\,n-1})$$

$$(\xi^i_{m-1,\,n}, \delta^i_{m-1,\,n}), \qquad (\xi^i_{m,n}, \delta^i_{m,n}),$$

where

$m - 1 = 0 \rightarrow 360$ and for $n = 169$

$$\xi^i_{m-1,\,169} = \xi^i_{m,\,169} = 9.999$$

$$\delta^i_{m-1,\,169} = \delta^i_{m,\,169} = 999.9$$

Check for land points and replace:

(a) if $\xi^i_{m,n-1} = 9.999$, replace $\theta \rightarrow 0$

(b) if $\xi^i_{m,n} = 9.999$, replace $\theta \rightarrow 1$

(c) if (a) and (b) hold, replace $\psi \rightarrow 1$

(d) if $\xi^i_{m-1,\,n-1} = 9.999$, replace $\bar{\theta} \rightarrow 0$

(e) if $\xi^i_{m-1,\,n} = 9.999$, replace $\bar{\theta} \rightarrow 1$

(f) if (d) and (e) hold, replace $\psi \rightarrow 0$

If (c) and (f) hold (Land!), set

$$\xi^i_{n,k} = \delta^i_{j,k} = 0$$

and go to (3) below, otherwise interpolate $\xi_{j,k}$ on the ruled second-order surface in ψ and θ

$$\xi_{j,k} = (1 - \psi)\,[\theta \xi^i_{m,\,n-1} + (1 - \theta)\,\xi^i_{m,\,n}\,] + \psi\,[\bar{\theta}\,\xi^i_{m-1,\,n-1} + (1 - \bar{\theta})\,\xi^i_{m-1,\,n}\,]. \qquad (*)$$

Test for 360° phase jumps and replace

$$\text{if } \delta^i_{m,\,n-1} - \delta^i_{m,\,n} \begin{cases} > 180, \text{ replace } \delta^i_{m,\,n-1} \rightarrow \delta^i_{m,\,n-1} - 360 \\ < -180, \text{ replace } \delta^i_{m,\,n-1} \rightarrow \delta^i_{m,\,n-1} + 360 \end{cases}$$

$$\text{if } \delta^i_{m-1,\,n-1} - \delta^i_{m,n} \begin{cases} > 180, \text{ replace } \delta^i_{m-1,\,n-1} \rightarrow \delta^i_{m-1,\,n-1} - 360 \\ < -180, \text{ replace } \delta^i_{m-1,\,n-1} \rightarrow \delta^i_{m-1,\,n-1} + 360, \end{cases}$$

$$\text{if } \delta^i_{m-1,\,n} - \delta^i_{m,\,n} \begin{cases} > 180, \text{ replace } \delta^i_{m-1,\,n} \rightarrow \delta^i_{m-1,\,n} - 360 \\ < -180, \text{ replace } \delta^i_{m-1,\,n} \rightarrow \delta^i_{m-1,\,n} + 360 \end{cases}$$

Use adjusted δ's to interpolate $\delta_{j,k}$ by formula (*) with ξ replaced by δ. Now compute and replace (ocean loading effect, see Schwiderski and Szeto 1981)

$$\xi_{j,k} \rightarrow 0.9333\, \xi_{j,k}$$

Compute earth tide amplitude function

$$\bar{E}_j = \begin{cases} E_i \cos^2 \phi_j \quad \text{for } \nu_i = 2 \\ E_i \sin 2\phi_j \quad \text{for } \nu_i = 1 \\ \frac{1}{2} E_i (3 \cos^2 \phi_j - 2) \quad \text{for } \nu_i = 0 \end{cases}$$

Finally, compute geocentric harmonic constants by harmonic addition (cos and sin arguments in degrees).

$$\xi^i_{j,k} = \left\{ (\xi_{j,k})^2 + (\bar{E}_j)^2 + 2\bar{E}_j\, \xi_{j,k} \cos [\delta_{j,k} + \nu_i (\lambda_j - k + 1)] \right\}^{1/2}$$

$$\delta^i_{j,k} = \tan^{-1} \frac{\xi_{j,k} \sin \delta_{j,k} - \bar{E}_j \sin [\nu_i (\lambda_j - k + 1)]}{\xi_{j,k} \cos \delta_{j,k} + \bar{E}_j \cos [\nu_i (\lambda_j - k + 1)]}$$

where $0 \leqslant \delta \leqslant 2\pi$ in radians.

(3) If $j < 383$, replace $j \rightarrow j + 1$ and repeat (2) above.
If $j \nless 383$, print all data ($\xi^i_{j,k}$, $\delta^i_{j,k}$)
$j = 1, 2, \ldots, 383$ and k on the magnetic tape SST GTD I, II, or III depending on the mode i as described in Section 4.
If $k < 360$, replace $k \rightarrow k + 1$, $j \rightarrow 1$, and repeat (2) above.
If $k \ngtr 360$, stop program.

Note 3: The User's Guide and Program Listing of this program are presented in Appendix B. Evidently, by applying this program for all mode numbers i = 1, 2, 3, ... , 11, one generates the SST GTD Tapes I, II, and III described in Section 4.

4. NSWC STANDARD SATELLITE TRACK GEOCENTRIC TIDE DATA (SST GTD) TAPES I, II, AND III

The NSWC SST GTD Tapes I, II, and III contain the geocentric (including earth tide and loading effects) harmonic tidal constants; i.e., amplitudes and phases

$$\left(\xi^i_{j,k} \cdot \delta^i_{j,k}\right) \begin{cases} i = 1, 2, \dots, 11 \\ j = 1,2, \dots, 383 \\ k = 1,2, \dots, 360 \end{cases} \qquad (*)$$

generated by the SST GTD program described in Section 3. The data are defined on a 1° x 1° SST grid system, which is defined in Section 2 on the basis of an SST specified by the longitudes (East, in deg) and latitudes (North, in deg), respectively,

$$(\lambda_j, \phi_j) \quad (j = 1,2, \dots, 383) \qquad (**)$$

which are also listed on SST GTD Tape I.

Computationally, the tidal data (*) are arranged by modes i(= 1, 2, ... , 11) on the three magnetic tapes in the order shown in Table 1 below.

Table 1: Mode Arrangement on SST GTD Tapes

SST GTD I	$i = 1 : M_2$	$i = 2 : S_2$	$i = 3 : K_1$	$i = 4 : O_1$	SST
SST GTD II	$i = 5 : N_2$	$i = 6 : P_1$	$i = 7 : K_2$	$i = 8 : Q_1$	–
SST GTD III	$i = 9$: Mf	$i = 10$: Mm	$i = 11$: Ssa	–	–

In each mode i(= 1, 2, ... ,11), the tidal constants (*) are arranged by SST-numbers k (= 1, 2, ... , 360) in consecutive pairs of blocks with each block containing 384 words j (= 1,2, ... , 384). The first 383 words (in Format F10.8) in the first block are amplitudes $\xi^i_{j,k}$ (in m) and in the second block Greenwich phases $\delta^i_{j,k}$ (in rad). The last word (j = 384) in each block (in Formate I 10) gives the SST number k (= 1,2, ... , 360) of the block pair.

As shown in Table 1, the SST GTD Tape I contains two additional (final) blocks of 384 words j(= 1, 2, ... , 384) in Format F 10.6. The first 383 words in the first block represent the SST latitudes ϕ_j (in deg) and in the second block the SST longitudes λ_j (in deg). The last word j = 384 in the first block gives the SST spacing time $\Delta\tau$ (in sec), and in the second block the periodic longitude shift $\hat{\lambda}$ of the SST (in deg.).

All data have been blockwise generated on the corresponding magnetic tapes (Table 1) by the BUFFER-OUT Statement on the CDC 6700 computer. These tapes have the following standard properties: 7 track, BDC form, even parity, 556 bpi, and unlabeled.

Note: On land (see Schwiderski 1978c) all tide data (*) are set to zero (see Section 3), i.e.

$$\xi^i_{j,k} = \delta^i_{j,k} = 0 \text{ for land.}$$

5. NSWC SATELLITE TRACK TIDE (STT) PROGRAM

The NSWC STT program uses the SST GTD Tapes I, II, and III described in Sections 3 and 4 to compute efficiently instantaneous geocentric tides at equidistant points and instances along "constrained satellite (say, SEASAT) tracks CST's" that are essentially parallel-displaced segments of the basic SST defined in Section 2 (see Figures 1, 2, and 3). The computed geocentric tides include the ocean tides superposed with the corresponding earth tides and earth dips in response to the oceanic tidal loads (see Schwiderski and Szeto 1981). When all leading tidal modes (M_2, S_2, K_1, O_1, N_2, P_1, K_2, Q_1, Mf, Mm, and Ssa; see Table 2) are included, the resulting instantaneous tidal elevations carry a 10-cm accuracy anywhere over open ocean areas (see Schwiderski 1978a, b, 1979a–e, 1980, 1981a–j, and 1982a–d). This accuracy diminishes somewhat in coastal waters where special improved computations are suggested in Schwiderski (1981j) and Schwiderski and Szeto (1981).

Definition of Constrained Satellite Tracks (CST)

A CST is a uniformly spaced (at least two points) segment of a satellite ground track, which (see Figure 3):

(a) Is ***almost parallel*** (congruent) to the basic SST of the SST GTD Tapes I, II, and III defined in Sections 2, 3, and 4.

(b) Is ***gridwise continuous***, i.e., it is without gaps in equidistant spacing points.

(c) Lies ***almost entirely between*** the track's two consecutive ***ascending nodal points*** on the equator.

(d) Lies ***almost entirely over*** the global ***ocean area*** specified by non-zero tidal constants listed on the SST GTD Tapes I, II, and III of Section 4.

Note 1: If condition (a) is violated, say, by more than 0.5° along the given CST when shifted to coincide with the SST, then a new appropriate SST and corresponding, SST GTD tapes ***must*** be prepared (see Sections 2, 3, and 4).

Note 2: Satellite tracks that are not gridwise continuous, cross the equator, say, by more than 5 sec and/or pass over land areas ***must*** be broken up into separate segments of CSTs to fulfill the conditions (b, c, and d) above.

A. Input Data:

(1) y = year $\geq$ 1975 (fixed for one run!)
(2) d = day of year y (d = 1 for January 1st, also fixed for one run!)

(3) t_1 = initial time (in sec) of first CST point (λ_1, ϕ_1) relative to Greenwich midnight of day d (universal time)

(4) Δt = constant time step (in sec) along CST

(5) N (>1) = total number of CST points

(6) (λ_n, ϕ_n) = longitudes (East) and latitudes of first two (n = 1, 2) CST points (in deg.)

(7) (λ_a, λ_b) = equator-crossing longitudes (in deg.) corresponding to the two consecutive ascending nodes of the track containing the CST

(8) (t_a, t_b) = equator-crossing times (in sec) relative to Greenwich midnight of day d, (d + 1), or (d − 1) for t_a *belonging to* λ_a *and of day* d, (d − 1), or (d + 1) for t_b belonging to λ_b

(9) ($\xi^i_{j,k}$, $\delta^i_{j,k}$) = geocentric tidal amplitudes (in m) and Greenwich phases (in rad) from SST GTD Tapes I, II, and III, where
i = 1, 2, ... , I ($\leqslant$ 11) = mode numbers
j = 1,2, ... , 383 = SST spacing points
k = 1,2, ... , 360 = SST ordinate lines (see Figures 2 and 3)

(10) I = total number of tidal modes (1 $\leqslant$ I $\leqslant$ 11) to be superposed

(11) $\Delta\tau$ = SST time step from SST GTD Tape I (in sec)

(12) $\hat{\lambda}$ = period longitude shift (in deg) of SST from SST GTD Tape I

Note 3: The CST data (3, 4, 5, and 6) ***must*** satisfy the CST definition above, necessary splits will be requested!

Note 4: For the equator-crossing longitudes (λ_a, λ_b) and the corresponding times t_a and t_b error bounds of less than 0.1° and 1.0 sec, respectively, are strongly recommended. Errors of more than 0.4° and 4.0 sec will be ***rejected*** for corrections (see B(3) and (4) below).

Note 5: The tidal data

$\xi^i_{j,k} = \delta^i_{j,k} = 0$ signal land, and

$\delta^i_{j,k} = 2\pi = 0$ a phase jump.

Table 2. Constants of Major Tidal Modes

Tidal Mode	*K* (m)	σ (10^{-4}/sec)	χ (deg)
	Semidiurnal Species		
M_2 = Principal Lunar	0.242 334	1.405 19	$2h_0 - 2s_0$
S_2 = Principal Solar	0.112 841	1.454 44	0
N_2 = Elliptical Lunar	0.046 398	1.378 80	$2h_0 - 3s_0 + p_0$
K_2 = Declination Luni-Solar	0.030 704	1.458 42	$2h_0$
	Diurnal Species		
K_1 = Declination Luni-Solar	0.141 565	0.729 21	$h_0 + 90$
O_1 = Principal Lunar	0.100 574	0.675 98	$h_0 - 2s_0 - 90$
P_1 = Principal Solar	0.046 843	0.725 23	$-h_0 - 90$
Q_1 = Elliptical Lunar	0.019 256	0.649 59	$h_0 - 3s_0 + p_0 - 90$
	Long-Period Species		
Mf = Fortnightly Lunar	0.041 742	0.053 234	$2s_0$
Mm = Monthly Lunar	0.022 026	0.026 392	$s_0 - p_0$
Ssa = Semiannual Solar	0.019 446	0.003 9821	$2h_0$

K = amplitude of the partial tide
σ = frequency of the partial tide
χ = astronomical argument of the partial tide
(h_0, s_0, p_0) = mean longitudes of sun, moon, and lunar perigee at Greenwich midnight
$h_0 = 279.696\,68 + 36\,000.\,768\,925\,485T + 3.03 \cdot 10^{-4} T^2$
$s_0 = 270.434\,358 + 481\,267.883\,141\,37T - 0.001\,133T^2 + 1.9 \cdot 10^{-6}\,T^3$
$p_0 = 334.329\,653 + 4\,069.034\,032\,957\,5T - 0.010\,325T^2 - 1.2 \cdot 10^{-5}\,T^3$

where

$T = [27\,392.500\,528 + 1.000\,000\,035\,6D]/36\,525$
$D = d + 365(y - 1975) + \text{Int}\,[(y - 1973)/4]$
d = day number of year (d = 1 for January 1)
$y \geq 1975$ = year number,

and

Int [x] = integral part of x

B. Computation of SST Grid Brackets and Other Constants for CST

In the following preliminary computations, the given CST will be bracketed between two consecutive SST grid ordinates k and (k + 1) as shown in Figure 3. Subsequently, time and space constants will be computed, which are needed in the following main computations.

(1) Transfer to core memory the CST data

y, d, t_1, Δt, N, t_a, t_b, λ_a, λ_b, (λ_1, ϕ_1), (λ_2, ϕ_2), and from the SST GTD Tape I the SST data

$$\Delta\tau \text{ and } \hat{\lambda}.$$

(2) Compute and adjust day count

$$\lambda' = 360 - \lambda_b + \lambda_a \ (+\,360 \text{ if} < 360),$$

$$\hat{t} = t_b - t_a \ (+\,86400 \text{ if} < 0),$$

$$\hat{\tau} = 380\,\Delta\tau, \tau_1 = t_1 - t_a.$$

If $\tau_1 > 3\hat{t}$, replace

$$\tau_1 \rightarrow \tau_1 - 86400, t_1 \rightarrow t_1 - 86400, d \rightarrow d + 1.$$

If $\tau_1 < -3\hat{t}$, replace

$$\tau_1 \rightarrow \tau_1 + 86400, t_1 \rightarrow t_1 + 86400, d \rightarrow d - 1.$$

(3) Compute and check

$$\tau_N = \tau_1 + (N - 1)\,\Delta t.$$

If $\tau_1 < -\Delta\tau/2$ and/or $\tau_N - \hat{\tau} > \Delta\tau/2$, stop and print: Check Track Data! Otherwise compute and replace

$$\Delta t \rightarrow \Delta t\,\hat{\tau}/\hat{t}, \quad t_\epsilon = t_a,$$

$$\tau_1 \rightarrow \tau_1\,\hat{\tau}/\hat{t}$$

$$\lambda_\epsilon = \lambda_a + \frac{1}{2}(\lambda' - \hat{\lambda}) \begin{cases} +\,360 \text{ if } < 0 \\ -\,360 \text{ if } > 360 \\ +\,0 \text{ otherwise.} \end{cases}$$

(4) If $|\tau_1| < \Delta\tau$ compute

$$\phi = \phi_1/(\phi_2 - \phi_1),$$

$$\Delta\lambda_1 = \lambda_1 - \lambda_2 \text{ (+ 360 if } < 0),$$

$$\Delta\lambda = \lambda_\epsilon - \lambda_1 \text{ (+ 360 if } < -10),$$

$$\Delta\lambda' = \phi\Delta\lambda_1,$$

$$\tau_i' = \phi\Delta t.$$

If $|\tau_1 - \tau_i'| > 0.4\ \Delta\tau$

and/or

$$|\Delta\lambda - \Delta\lambda'| > 0.4,$$

stop and print: Check Track Data! Otherwise replace

$$t_\epsilon \rightarrow t_\epsilon + \tau_1 - \tau_i', \tau_1 \rightarrow \tau_i',$$

$$\lambda_\epsilon \rightarrow \lambda_1 + \Delta\lambda' \begin{cases} +360 \text{ if} < 0 \\ -360 \text{ if} > 360 \\ +0 \text{ otherwise.} \end{cases}$$

(5) Compute the CST bracket data (see Figure 3)

$$k = \text{Int}\,[361 - \lambda_\epsilon], \lambda = (361 - \lambda_\epsilon) - k.$$

Replace

$$k = 361 \rightarrow 1.$$

Compute and replace

$$J = \text{Int}\,[2 + \tau_1/\Delta\tau],$$

$$M = \text{Int}\,[4 - J + \tau_N/\Delta\tau],$$

$$\tau_1 \rightarrow \tau_1 - (J - 2)\Delta\tau$$

(6) Compute the constants

$$\Delta\tilde{\tau} = 1/\Delta\tau,\ \tilde{\tau}_1 = \Delta\tilde{\tau}/2,\ \tilde{\tau}_2 = \tilde{\tau}_1\ \Delta\tilde{\tau}, \tilde{\tau}_3 = \tilde{\tau}_2\ \Delta\tilde{\tau}$$

With the tidal parameters h_0, s_0, p_0, and (σ_i, χ_i; i = 1, 2, ... , 11) listed in Tables 1 and 2 computed for i = 1, 2, ... ,11.

$$\bar{\sigma}_i = \sigma_i\ \Delta\tau\ , \bar{\chi}_i = \sigma_i t_\epsilon - 2\ \bar{\sigma}_i + \pi\chi_i/180$$

Keep the constants I, J, k, M, N, λ, Δt, Δτ, $\Delta\tilde{\tau}$, τ_1, $\tilde{\tau}_1, \tilde{\tau}_2, \tilde{\tau}_3$, and ($\bar{\sigma}_i$, $\bar{\chi}_i$; i = 1, 2, ... ,11) for the main computations.

C. First Rough Interpolation

In this first step tidal amplitudes and phases are mode-wise linearly interpolated at the SST-spacing points on the CST using the data along the neighboring SST ordinate lines k and (k + 1) as shown in Figure 3. Subsequently, instantaneous geocentric tides $\bar{\zeta}_m$ are computed from the interpolated harmonic constants, which are automatically mode-wise superposed.

(1) Set: i = 1 and $\bar{\zeta}_m$ = 0 for m = 1, 2, ... , M

(2) Transfer to core memory the tidal constants

$(\xi^i_{j,k}, \delta^i_{j,k})$ and $(\xi^i_{j,k+1}, \delta^i_{j,k+1})$

for j = 1,2, ... , 383 and i and k fixed (k + 1 = 361 → 1!)

Set

j = J, m = 1

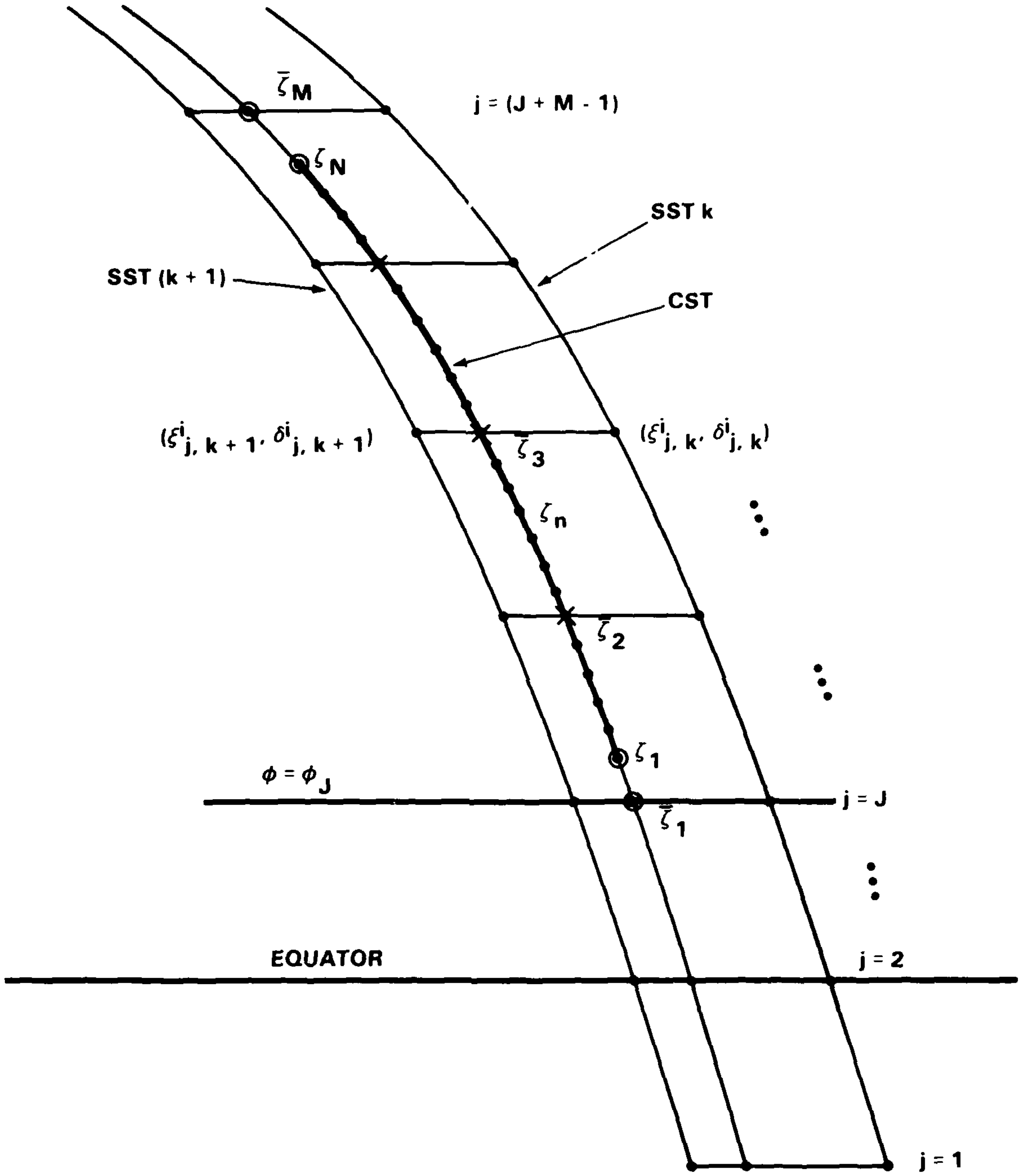

Figure 3. Scheme of Tide Interpolation

ⓧ, x = SST Spacing Points on CST

⊙ • = CST Spacing Points on CST

(3) Check for land points and define (λ_1, λ_2) as follows

$$\text{For } \xi^i_{j,k} \begin{cases} > 0 \text{ set } \lambda_2 = \lambda \\ \not> 0 \text{ set } \lambda_2 = 1 \end{cases}$$

$$\text{For } \xi^i_{j,k+1} \begin{cases} > 0 \text{ set } \lambda_1 = 1 - \lambda \\ \not> 0 \text{ set } \lambda_1 = 1 \end{cases}$$

Now interpolate linearly

$$\xi_m = \lambda_1 \xi^i_{j,k} + \lambda_2 \xi^i_{j,k+1} \qquad (*)$$

check for 2π-phase jumps and replace δ's for

$$\delta^i_{j,k} - \delta^i_{j,k+1} \begin{cases} > \pi \text{ replace } \delta^i_{j,k+1} \rightarrow \delta^i_{j,k+1} + 2\pi \\ < -\pi \text{ replace } \delta^i_{j,k} \rightarrow \delta^i_{j,k} + 2\pi \end{cases}$$

Use adjusted δ's to compute δ_m by *formula* (*) with $\xi \rightarrow \delta$

Now compute the superposed *instantaneous tide*

$$\bar{\zeta}_m \rightarrow \bar{\zeta}_m + \xi_m \cos(\bar{\sigma}_i j + \bar{\chi}_i - \delta_m)$$

If $m < M$, replace $m \rightarrow m + 1$, $j \rightarrow j + 1$, and repeat (3) above. If $(m \not< M)$, go to (4) below.

(4) If $i < I$, replace $i \rightarrow i + 1$ and repeat (2) above.

If $(i \not< I)$, follow D below, but keep the constants M, N, Δt, $\Delta\tau$, $\Delta\tilde{\tau}$, τ_1, $\tilde{\tau}_1$, $\tilde{\tau}_2$, $\tilde{\tau}_3$, and $\bar{\zeta}_m$ (m = 1,2, ... , m).

D. Second Refined Interpolation

The finally desired instantaneous geocentric tides ζ_n $(n = 1,2, \ldots, N)$ at the given CST spacing points are generally computed by a "cubic-parabolic spline" interpolation to achieve a smooth tangent variation along the ζ_n. In order to compute the tide ζ_n, say, between the SST-spaced data $\bar{\zeta}_2$ and $\bar{\zeta}_3$ (see C and Figure 3) a "cubic" polynomial is forced through $\bar{\zeta}_2$ and $\bar{\zeta}_3$ with the corresponding "parabolic" slopes

$$\bar{\xi}'_m = (\bar{\zeta}_{m+1} - \bar{\zeta}_{m-1})/\tau_1 \text{ for } m = 2, \text{ and } 3$$

Naturally, for shorter CSTs; e.g., between land areas (signaled by $\bar{\zeta} = 0$ data) only ordinary parabolic or linear interpolation is used. In detail, the following tests must be made, which lead to the different interpolation cases 1, 2, 3, 4, and (subsequently) 5.

(1) If $M > 2$ ***and*** $\bar{\zeta}_2 \neq 0$, ***and***

(1.1) $\bar{\zeta}_3 \neq 0$, ***and***

(1.1.1) $\bar{\zeta}_1 \neq 0$, set

$\tau = \tau_1$, $m = 1$, $n = 1$, and go to case 3

(1.1.2) ($\bar{\zeta}_1 = 0$), set

$\tau = \tau_1 - \Delta\tau$, $m = 2$, $n = 1$, ***and***

(1.1.2.1) for $M > 3$ ***and*** $\bar{\zeta}_4 \neq 0$, go to case 3

(1.1.2.2) otherwise go to case 2

(1.2) ($\bar{\zeta}_3 = 0$), ***and***

(1.2.1) $\bar{\zeta}_1 \neq 0$, set

$\tau = \tau_1$, $m = 1$, $n = 1$ and go to case 2

(1.2.2) ($\bar{\zeta}_1 = 0$), go to case (1)

(2) If (1) fails ***and***

(2.1) $M \not> 2$, $\bar{\zeta}_2 \neq 0$, ***and*** $\bar{\zeta}_1 \neq 0$, set $\tau = \tau_1$, $m = 1$, $n = 1$, and go to case 2

(2.2) otherwise go to case 1

Now compute the interpolutions

Case 1. Constant interpolation for one oceanic datum $\bar{\zeta}_1 \neq 0$ or $\bar{\zeta}_2 \neq 0$

Compute

$$\zeta_n = \bar{\zeta}_1 + \bar{\zeta}_2 \text{ for } n = 1, 2, \ldots, N, \text{ and go to E}$$

Case 2: Linear interpolation for two oceanic data $\bar{\zeta}_m \neq 0$ and $\bar{\zeta}_{m+1} \neq 0$

With $a = \Delta\tilde{\tau}(\bar{\zeta}_{m+1} - \bar{\zeta}_m)$, $b = a\,\Delta t$, compute

$$\zeta_1 = \bar{\zeta}_m + a\,\tau, \text{ for } n = 1$$

$$\zeta_n = \zeta_{n-1} + b, \text{ for } n = 2, 3, \ldots, N, \text{ and go to E}$$

Case 3: Parabolic interpolation for three oceanic data $\bar{\zeta}_m \neq 0$, $\bar{\zeta}_{m+1} \neq 0$, and $\bar{\zeta}_{m+2} \neq 0$

(a) Compute:

$a = \tilde{\tau}_1 (-3\,\bar{\zeta}_m + 4\,\bar{\zeta}_{m+1} - \bar{\zeta}_{m+2})$, $b = \tilde{\tau}_2 (\bar{\zeta}_m - 2\,\bar{\zeta}_{m+1} + \bar{\zeta}_{m+2})$, and go for

$M < m + 3$, or $\bar{\zeta}_{m+3} = 0$ to (b), otherwise go to (c)

(b) Compute

$$\zeta_n = (b\tau + a)\,\tau + \bar{\zeta}_m$$

If $n < N$, replace $n \rightarrow n + 1$, $\tau \rightarrow \tau + \Delta t$, and repeat (b).

If $(n \not< N)$, go to E.

(c) Compute

$$\zeta_n = (b\tau + a)\,\tau + \bar{\zeta}_m$$

Replace $n \rightarrow n + 1$ and $\tau \rightarrow \tau + \Delta t$

If $\tau < \Delta\tau$, repeat (c)

If $(\tau \not< \Delta\tau)$, replace $\tau \rightarrow \tau - \Delta\tau$, $m \rightarrow m + 1$, and go to Case 4 below.

Case 4: Cubic-parabolic interpolation for four oceanic data, $\bar{\zeta}_{m-1} \neq 0$, $\bar{\zeta}_m \neq 0$, $\bar{\zeta}_{m+1} \neq 0$, and $\zeta_{m+2} \neq 0$:

(a) Compute

$a = \tilde{\tau}_1 (\bar{\zeta}_{m+1} - \bar{\zeta}_{m-1})$, $b = \tilde{\tau}_2 (2\,\bar{\zeta}_{m-1} - 5\,\bar{\zeta}_m + 4\,\bar{\zeta}_{m+1} - \bar{\zeta}_{m+2})$

$c = \tilde{\tau}_3 (\bar{\zeta}_{m+2} - 3\,\bar{\zeta}_{m+1} + 3\,\bar{\zeta}_m - \bar{\zeta}_{m-1})$, and go to (b) below

(b) Compute

$\zeta_n = [(c\tau + b)\tau + a)]\tau + \bar{\zeta}_m$

Replace $n \rightarrow n + 1$ and $\tau \rightarrow \tau + \Delta t$

If $\tau < \Delta\tau$, repeat (b)

If $(\tau \nless \Delta\tau)$, replace $\tau \rightarrow \tau - \Delta\tau$, and $m \rightarrow m + 1$, ***and*** if $M < m + 2$, ***or*** $\bar{\zeta}_{m+2} = 0$, go to Case 5, otherwise repeat (a) above.

Case 5: Parabolic end-point interpolation for three oceanic data $\bar{\zeta}_{m-1} \neq 0$, $\bar{\zeta}_m \neq 0$, and $\bar{\zeta}_{m+1} \neq 0$:

(a) Compute

$a = \tilde{\tau}_1 (\bar{\zeta}_m - \bar{\zeta}_{m-1})$, $b = \tilde{\tau}_2(\bar{\zeta}_{m+1} - 2\bar{\zeta}_m + \bar{\zeta}_{m-1})$, and go to (b) below

(b) Compute

$\zeta_n = (b\tau + a)\tau + \bar{\zeta}_m$

If $n < N$, replace $n \rightarrow n + 1$, $\tau \rightarrow \tau + \Delta t$ and repeat (b)

If $(n \nless N)$, go to E

E. Output Data

List and/or print on tape all tidal data

$$\zeta_n : n = 1, 2, \ldots, N$$

as specifically requested.

Note 5: The User's Guide and Program Listing of this program are given in Appendix C.

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APPENDIX A

SST PROGRAM USER'S GUIDE AND PROGRAM LISTING

APPENDIX A

1. SST PROGRAM USER'S GUIDE

The Standard Satellite Track (SST) program generates from a given Approximate Standard Satellite Track (ASST) (see Section 2, Part A) an Exact Standard Satellite Track (ESST) that is used by the SSTGTD (see Section 3) program.

The following listing shows the SST program written in CDC Fortran Extended for the CDC 6700 computer under the SCOPE 3.4 operating system.

Input to the SST program consist of the ASST file attached to TAPE1 and a data card containing the orbital period in seconds with E20.9 format. The computed ESST is written onto a file called TAPE2. This ESST will be called the SST.

2. SST PROGRAM LISTING

```
PROGRAM SST        73/74   OPT=1                    FTN 4.6+433        01/14/83  17.14.35        PAGE     1

                PROGRAM SST(INPUT,OUTPUT
             *  ,TAPE1, TAPE2)
      C         ..
      C         ..SST(STANDARD SATELLITE TRACK) PROGRAM
      C   AUTHOR
      C         L. T. SZETO
      C   LANGUAGE
      C         CDC FORTRAN EXTENDED
      C         ..
                REAL LONG(384), LAT(384)
                REAL LATP(384), LONGP(384)
      C         ..READ IN ASST(APPROXIMATE STANDARD TRACK) DATA
                READ(1) (( LAT(I), LONG(I)),I=1,381)
      C         CHECK MINIMUM APPROXIMATE CONDITIONTO AVOID
      C         SIGNIFICANT LOSSES IN ACCURACY.
                CALL CHECK( LAT)
                READ 5,PERIOD
          5     FORMAT(E20.9)
                SPACIN= PERIOD/380.
                DL1= LONG(1)- LONG(2)
                IF(DL1.LT.O.) DL1=DL1+360.
                DP1= LAT(2)- LAT(1)
                DL= LONG(380)- LONG(381)
                IF( DL.LT.O.) DL=DL+360.
                DP= LAT(381)- LAT(380)
                DT1= SPACIN*LAT(1)/ DP1
                DT=  SPACIN*LAT(381)/ DP
                THP= PERIOD- ( DT- DT1)
                DTT= ( DT- DT1)/380.
                V= SQRT( DL1*DL1+ DP1*DP1)/ SPACIN
                RL=360.- LONG(1)- LAT(1)*DL1/ DP1
                RRL= RL+ LONG(381)+ LAT(381)*DL / DP
                LONGP(382)= AMOD( RRL,360.)
      C         ..
      C         GENERATE THE BASIC SST
                DO 300 J=2,380
      C              JP1=3,381
                     DT1= DT1+ DTT
                     JM1=J-1
                     JP1=J+1
      C              JP1=3,381
                     DL= LONG(JM1)- LONG(JP1)
                     IF(DL.LT.O.) DL=DL+360.
                     DP= LAT(JP1)- LAT(JM1)
                     S= V*DT1/ SQRT( DL*DL+ DP*DP)
                     LONGP(JP1)= LONG(J)+ S*DL+ RL
                     LONGP(JP1)= AMOD( LONGP(JP1),360.)
                     LATP(JP1)= LAT(J)- S*DP
        300          CONTINUE
      C         ENDDO
                LONG(1)= 360.- LONGP(3)
                LONG(2)= 360.
                LAT(1)= -LATP(3)
                LAT(2)=O.
                LONG(382)= LONGP(382)
                LONG(383)= LONGP(382)*2.- LONGP(381)
                LAT(382)=O.
```

```
      PROGRAM SST        73/74    OPT=1                            FTN 4.6+433        01/14/83  17.14.35        PAGE      2

                                LAT(383)=-LATP(381)
                                DO 500 J=3,381
  60                                 LONG(J)= LONGP(J)
                                     LAT(J)= LATP(J)
                    500              CONTINUE
                  C             ENDDO
                  C             ..
  65              C             LAT(384)=SST SPACING TIME IN SECONDS
                                LAT (384)= THP/380.
                  C             ..LONG(384)=PERIODIC LONGITUDE SHIFT OF THF THE SST IN DEGREES
                                LONG(384)=720.-LONG(382)
                                WRITE(2) (LAT(I),I=1,384)
  70                            WRITE(2)(LONG(I),I=1,384)
                                END


      SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE     REFERENCES
10222  SST            1

VARIABLES     SN  TYPE            RELOCATION
10435  DL         REAL                        REFS      2*24      32      2*43      2*45       46
                                           DEFINED        23      24        42        43
10433  DL1        REAL                        REFS      2*21    2*30        31   DEFINED       20        21
10436  DP         REAL                        REFS        27      32      2*45        48  DEFINED        25        44
10434  DP1        REAL                        REFS        26    2*30        31   DEFINED       22
10440  DT         REAL                        REFS        28      29   DEFINED        27
10442  DTT        REAL                        REFS        38 DEFINED        29
10437  DT1        REAL                        REFS        28      29        38        45  DEFINED        26        38
10430  I          INTEGER                     REFS      2*13      69        70   DEFINED       13        69        70
10446  J          INTEGER                     REFS        39      40        46        48     2*60      2*61
                                           DEFINED        36      59
10447  JM1        INTEGER                     REFS        42      44   DEFINED        39
10450  JP1        INTEGER                     REFS        42      44        46      2*47       48
                                           DEFINED        40
11252  LAT        REAL          ARRAY         REFS        10      16      2*22      2*25       26        27        31
                                                32      2*44      48        69   DEFINED       13        53        54
                                                57        58      61        66
12052  LATP       REAL          ARRAY         REFS        11      53        58        61  DEFINED        48
10452  LONG       REAL          ARRAY         REFS        10    2*20      2*23        31       32      2*42        46
                                                68        70 DEFINED        13        51       52        55        56
                                                60        68
12652  LONGP      REAL          ARRAY         REFS        11      47        51        55     2*56        60
                                           DEFINED        33      46        47
10431  PERIOD     REAL                        REFS        19      28   DEFINED        17
10444  RL         REAL                        REFS        32      46   DEFINED        31
10445  RRL        REAL                        REFS        33 DEFINED        32
10451  S          REAL                        REFS        46      48   DEFINED        45
10432  SPACIN     REAL                        REFS        26      27        30   DEFINED       19
10441  THP        REAL                        REFS        66 DEFINED        28
10443  V          REAL                        REFS        45 DEFINED        30
```

```
         PROGRAM SST         73/74   OPT=1                        FTN 4.6+433        01/14/83  17.14.35        PAGE     3

FILE NAMES          MODE
    0  INPUT      FMT                        READS        17
 2043  OUTPUT
 4106  TAPE1      UNFMT                      READS        13
 6151  TAPE2      UNFMT                     WRITES        69         70

EXTERNALS              TYPE    ARGS         REFERENCES
       CHECK                    1               16
       SQRT       REAL          1 LIBRARY       30        45

INLINE FUNCTIONS       TYPE    ARGS         DEF LINE   REFERENCES
       AMOD       REAL          2  INTRIN                 33         47

STATEMENT LABELS                   DEF LINE    REFERENCES
10414  5           FMT                18          17
    0  300                            49          36
    0  500                            62          59

LOOPS  LABEL      INDEX      FROM-TO     LENGTH     PROPERTIES
10226           * I           13 13        10B                   EXT REFS
10310  300      * J           36 49        34B                   EXT REFS
10361  500        J           59 62        4B        INSTACK

STATISTICS
  PROGRAM LENGTH                 3236B      1694
  BUFFER LENGTH                 10214B      4236
```

```
SUBROUTINE CHECK      73/74   OPT=1                         FTN 4.6+433      01/14/83  17.14.35       PAGE      1

 1                    SUBROUTINE CHECK( LAT)
                      REAL LAT(384)
                      A1= ABS( LAT(1))
                      A381=ABS(LAT(381))
 5                    IF(.NOT.((A1.LT.O.5).AND.(A381.LT.O.5))) GO TO20
                           RETURN
                20         CONTINUE
              C       ENDIF
                      PRINT30
 10             30    FORMAT(*ERROR*)
                      STOP " STOPPED IN CHECK SUBROUTINE"
                      END


   SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE     REFERENCES
   3  CHECK           1            6

VARIABLES      SN  TYPE          RELOCATION
   26  A1          REAL                           REFS      5   DEFINED      3
   27  A381        REAL                           REFS      5   DEFINED      4
    0  LAT         REAL       ARRAY    F.P.       REFS      2        3       4    DEFINED     1

FILE NAMES        MODE
     OUTPUT     FMT                      WRITES       9

INLINE FUNCTIONS   TYPE    ARGS        DEF LINE  REFERENCES
     ABS           REAL      1  INTRIN                 3          4

STATEMENT LABELS                DEF LINE     REFERENCES
   14  20                          7             5
   22  30       FMT               10             9

STATISTICS
  PROGRAM LENGTH                 34B         28
```

APPENDIX B

SSTGTD PROGRAM USER'S GUIDE AND PROGRAM LISTING

APPENDIX B

1. SSTGTD PROGRAM USER'S GUIDE

The standard Satellite Track Geocentric Tide Data (SSTGTD) program generates geocentric harmonic constants at SST (see Section 2) grid points. This data will be used by the STT (Section 5) program.

The following program listing shows SSTGTD written in CDC Fortran Extended for the CDC 6700 computer under the SCOPE 3.4 operating system.

Input for the SSTGTD program consist of three files and two other values using the free-format READ statement. These two values are the species number and the earth-tide amplitude of the tide that is being processed. The computed values are put on two other files (TAPE4 and TAPE5).

The following gives the control cards and data card for a sample run of the SSTGTD program for the M_2 tide.

⟨job card⟩
⟨account card⟩
FTN, R=3, A.
ATTACH, TAPE2, the SST file generated by the SST (Section 2) program.
ATTACH, TAPE1, $\xi^i_{m,n}$ (amplitude in meters)
ATTACH, TAPE3, $\delta^i_{m,n}$ (phase in degrees)

} m = 1, 2,..., 360 (longitude number)
n = 1,2,..., 168 (colatitude number)
i = tidal mode being processed
Tapes 1 and 3 contain GOTD values made randomly accessible by colatitude number n.

REQUEST, TAPE4, *PF.
REQUEST, TAPE5, *PF.
LGO.
CATALOG, TAPE4, $\xi^i_{j,k}$ (amplitudes in meters)
CATALOG, TAPE 5, $\delta^i_{j,k}$ (phases in radians)

} j = 1,2,..., 383 (SST points)
k = 1,2,..., 360 (SST number)
i = tidal mode being processed

⟨end of record⟩
⟨SSTGTD program⟩
⟨end of record⟩
⟨data card⟩ for i = 1 (M_2 tide): ⟨2, 0.148308⟩

2. SST GTD PROGRAM LISTING

```
      PROGRAM SSTGTD(INPUT=65,OUTPUT=65,TAPE1=65
     * ,TAPE2,TAPE3=65
     *      , TAPE4=65, TAPE5=65 )
C     ..SSTGTD(STANDARD SATELLITE TRACK GEOCENTRIC TIDE DATA) PROGRAM
C          FORMERLY CALLED SSSTDT.
C  AUTHOR
C     L. T. SZETO
C  LANGUAGE
C     CDC FORTRAN EXTENDED
C     CALLS TO
C          ETIDE
C          GTD
C          JUMPS
C          LATLON

      REAL LAM
      DIMENSION XDJK(768), XJK(384), DJK(384)
      DIMENSION LVL(192),L4(170),XN(361), X(361)
      EQUIVALENCE (XDJK(1), XJK(1)),( XDJK(385), DJK(1))
C
C     **SETUP RANDOM ACCESS FILE ON UNITS 1 AND 3
      CALL OPENMS( 1,LVL, 192,0)
      CALL OPENMS(3,L4,170,0)
      PI=3.14159
      ISST=2
      DTR= PI/180.
C     **INPUT THE SPECIES(NU) AND EARTH TIDE AMPLITUDE(E)
C     ** FOR THE CORRESPONDING TIDAL MODE.
      READ*,NU,E

C     **FOR EACH STANDARD SATELLITE TRACK(SST) NUMBER(K).
      DO 6000 K=1,360
C          **GENERATE AMPLITUDES AND PHASES(XJK(J),DJK(J)) FOR THE
C          **TOTAL GEOCENTRIC PARTIAL TIDE AT EACH SST POINT(J).
           DO 4000 J=1,383
                CALL LATLON
     G                     ( K, J ,ISST
     Y                     , PHI, LAM, M, N, T, TB
     B                     , PSI )
C               LATITUDE AND LONGITUDE(PHI,LAM) OF SST
C               ARE IN DEGREES.
C                ..
               IF(.NOT.(N.GT.169)) GO TO 1020
                XJK(J)=0.
                DJK(J)=0.
                GO TO 3055
C              ELSE
 1020           CALL GTD
     G                 (N,M
     Y                 ,XD,X
     Y                 ,XN,DMN,DM1N,MM1,DMN1,DM1N1
     B                 , PSI, T, TB, ICF )
                IF(.NOT.(ICF.EQ.1)) GO TO 1050
                     XJK(J)=0.
                     DJK(J)=0.
                     GO TO 3050
C               ELSE
```

```
 1050               CONTINUE
C                   INTERPOLATE
                    T1=1.-T
                    TB1=1.-TB
                    PSI1=1.-PSI
                    XJK(J)= PSI1*(XN(M)*T+T1*X(M))
     *                     +PSI*(XN(MM1)*TB+TB1*X(MM1))
C                   ADD OCEAN LOADING EFFECT.
                    XJK(J)= XJK(J)* 0.933333
C                   ..
C                   **SKIP PHASE JUMP CHECK(JUMPS SUBROUTINE)
C                   **WHEN N,M ARE THE SAME (XD.LE.0.0) AS THE
C                   **PREVIOUSLY COMPUTED N,M.
                    IF(.NOT.(XD.GT.0.0)) GO TO 2080
                          CALL JUMPS(DMN,DM1N,DMN1,DM1N1)
 2080                     CONTINUE
C                   ENDIF
C                   ..
C                   INTERPOLATE FOR DJK(J)
                           DJK(J)=PSI1*( DMN1*T+T1*DMN)
     *                      +PSI*(  DM1N1*TB+TB1*DM1N)
                    PHIR= PHI*DTR
                    CALL ETIDE
     G                          (E,PHIR,NU
     Y                          , EB )
C                   ..
C                   COMPUTE GEOCENTRIC HARMONIC CONSTANTS BY
C                   HARMONIC ADDITION.
                    EB2= EB*EB
                    XI= XJK(J)
                    XI2= XJK(J)*XJK(J)
                    DR= DJK(J)*DTR
                    RNULK1= DTR*NU*(LAM- K+1.)
                    XJK(J)=SQRT(XI2+EB2+2*EB*XI     *COS(DR+RNULK1))
                    D1T= XI*SIN(DR)- EB*SIN(RNULK1)
                    D1D= XI*COS(DR)+ EB*COS(RNULK1)
C                   ..
C                   **4 QUADRANT ARCTANGENT FUNCTION ARTNQ
C                   RETURNS DJK ,0.LE.DJK.LT.2*PI
                    DJK(J)= ARTNQ(D1T,D1D)
C                   XJK,DJK ARE IN METERS AND RADIANS RESPECTIVELY.
 3050               CONTINUE
C               ENDIF
 3055           CONTINUE
C             ENDIF
 4000           CONTINUE
            ENDDO
            XJK(384)=K
            BUFFER OUT(4,1) ( XJK(1), XJK(384))
            IF(UNIT(4)) 5020,12,13
 5020       DJK(384)=K
            BUFFER OUT(5,1) (DJK(1), DJK(384))
            IF(UNIT(5)) 5021,12,13
 5021       CONTINUE
 6000       CONTINUE
C       ENDDO
        PRINT6050
```

```
    115            6050      FORMAT(* *,*SSTGTD PROGRAM COMPLETED*)
                             CALL EXIT
                       12    STOP "12,STOPPED IN SSTGTD"
                       13    STOP "13,STOPPED IN SSTGTD"
                             END


        SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
 3170  SSTGTD        1

VARIABLES       SN  TYPE             RELOCATION
 4336  DJK          REAL        ARRAY           REFS      17       19      89    2*109  DEFINED     45      55
                                                  77      97      108
 3514  DMN          REAL                        REFS      48       72      77
 3517  DMN1         REAL                        REFS      48       72      77
 3515  DM1N         REAL                        REFS      48       72      77
 3520  DM1N1        REAL                        REFS      48       72      77
 3532  DR           REAL                        REFS      91       92      93   DEFINED     89
 3500  DTR          REAL                        REFS      79       89      90   DEFINED     26
 3535  D1D          REAL                        REFS      97  DEFINED      93
 3534  D1T          REAL                        REFS      97  DEFINED      92
 3502  E            REAL                        REFS      80  DEFINED      29
 3526  EB           REAL                        REFS      80     2*86      91      92      93
 3527  EB2          REAL                        REFS      91  DEFINED      86
 3521  ICF          INTEGER                     REFS      48       53
 3477  ISST         INTEGER                     REFS      36  DEFINED      25
 3504  J            INTEGER                     REFS      36       44      45      54      55      63    2*66
                                                  77      87     2*88      89      91      97
                                             DEFINED      35
 3503  K            INTEGER                     REFS      36       90     105     108  DEFINED     32
 3475  LAM          REAL                        REFS      16       36      90
 5136  LVL          INTEGER     ARRAY           REFS      18       22
 5436  L4           INTEGER     ARRAY           REFS      18       23
 3506  M            INTEGER                     REFS      36       48    2*63
 3516  MM1          INTEGER                     REFS      48     2*63
 3507  N            INTEGER                     REFS      36       43      48
 3501  NU           INTEGER                     REFS      80       90 DEFINED      29
 3505  PHI          REAL                        REFS      36       79
 3525  PHIR         REAL                        REFS      80  DEFINED      79
 3476  PI           REAL                        REFS      26  DEFINED      24
 3512  PSI          REAL                        REFS      36       48      62      63      77
 3524  PSI1         REAL                        REFS      63       77 DEFINED      62
 3533  RNULK1       REAL                        REFS      91       92      93  DEFINED     90
 3510  T            REAL                        REFS      36       48      60      63      77
 3511  TB           REAL                        REFS      36       48      61      63      77
 3523  TB1          REAL                        REFS      63       77 DEFINED      61
 3522  T1           REAL                        REFS      63       77 DEFINED      60
 6461  X            REAL        ARRAY           REFS      18       48    2*63
 3513  XD           REAL                        REFS      48       71
 3536  XDJK         REAL        ARRAY           REFS      17     2*19
 3530  XI           REAL                        REFS      91       92      93  DEFINED     87
 3531  XI2          REAL                        REFS      91  DEFINED      88
```

```
                                                                FTN 4.6+433       01/18/83  11.40.06        PAGE     4
          PROGRAM SSTGTD      73/74   OPT=1

VARIABLES      SN  TYPE            RELOCATION
 3536  XJK         REAL        ARRAY               REFS        17        19        66        87        2*88      2*106
                                                  DEFINED      44        54        63        66        91        105
                                                   REFS        18        48        2*63
 5710  XN          REAL        ARRAY

FILE NAMES         MODE
     0  INPUT      FREE                    READS       29
   142  OUTPUT     FMT                     WRITES      114
   304  TAPE1
   446  TAPE2
  2511  TAPE3                              WRITES      106
  2653  TAPE4      BUF                     WRITES      109
  3015  TAPE5      BUF

EXTERNALS              TYPE     ARGS          REFERENCES
          ARTNO        REAL      2               97
          COS          REAL      1 LIBRARY       91          2*93
          ETIDE                  4               80
          EXIT                   0              116
          GTD                   14               48
          JUMPS                  4               72
          LATLON                10               36
          OPENMS                 4               22          23
          SIN          REAL      1 LIBRARY      2*92
          SQRT         REAL      1 LIBRARY       91
          UNIT         REAL      1              107          110

STATEMENT LABELS                    DEF LINE    REFERENCES
  3345  12                            117          107         110
  3346  13                            118          107         110
  3212  1020                           48           43
  3221  1050                           58           53
  3243  2080                           73           71
  3321  3050                           99           56
  3321  3055                          101           46
     0  4000                          103           35
     0  5020         INACTIVE         108          107
     0  5021         INACTIVE         111          110
     0  6000                          112           32
  3455  6050     FMT                  115          114

LOOPS  LABEL    INDEX      FROM-TO     LENGTH     PROPERTIES
 3203  6000    * K          32 112      140B                  EXT REFS     EXITS    NOT INNER
 3204  4000    * J          35 103      120B                  EXT REFS

EQUIV CLASSES    LENGTH     MEMBERS - BIAS NAME(LENGTH)
    XDJK           768             0 XJK     (384) *           384 DJK     (384)

STATISTICS
  PROGRAM LENGTH                 4061B     2097
  BUFFER LENGTH                  3157B     1647
```

```
SUBROUTINE ETIDE      73/74   OPT=1                        FTN 4.6+433       01/18/83  11.40.06       PAGE      1

 1                    SUBROUTINE ETIDE
                G                        (E,PHIR,NU
                Y                        , EB)
           C    AUTHOR
 5         C        L. T. SZETO
           C    LANGUAGE
           C          CDC FORTRAN EXTENDED
           C          CALLED BY
           C                SSTGTD
10         C
                      IF(.NOT.(NU.EQ.1)) GO TO 4012
                            TEMP= SIN( 2*PHIR)
                            GO TO 4013
           C          ELSE
15          4012            COSPHI= COS(PHIR)
                            CPHI2= COSPHI*COSPHI
                            IF(NU.EQ.2) TEMP= CPHI2
           C                IF(NU.EQ.O) TEMP= (3.0*CPHI2-2.)/2.0
                            IF(NU.EQ.O) TEMP= 1.5*CPHI2-1.
20          4013            CONTINUE
           C          ENDIF
                      EB=E * TEMP
                      RETURN
                      END


   SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE     REFERENCES
   3  ETIDE          1            23

VARIABLES       SN  TYPE            RELOCATION
   33  COSPHI       REAL                          REFS        2*16   DEFINED      15
   34  CPHI2        REAL                          REFS        17        19    DEFINED      16
    O  E            REAL                F.P.      REFS        22     DEFINED       1
    O  EB           REAL                F.P.    DEFINED        1        22
    O  NU           INTEGER             F.P.      REFS        11        17        19    DEFINED      1
    O  PHIR         REAL                F.P.      REFS        12        15    DEFINED       1
   32  TEMP         REAL                          REFS        22     DEFINED      12        17        19

EXTERNALS            TYPE    ARGS        REFERENCES
        COS          REAL     1 LIBRARY      15
        SIN          REAL     1 LIBRARY      12

STATEMENT LABELS              DEF LINE     REFERENCES
   12  4012                      15            11
   25  4013                      20            13

STATISTICS
  PROGRAM LENGTH                 35B        29
```

```
                 SUBROUTINE GTD
         G                          ( N, M
         Y                            ,XD,X
         Y                            ,XN,DMN,DM1N,MM1,DMN1,DM1N1
         B                          ,PSI,T,TB,ICF )
C     AUTHOR
C         L. T. SZETO
C     LANGUAGE
C          CDC FORTRAN EXTENDED
C          CALLED BY
C                SSTGTD
C
           DIMENSION XN(361),  X(361),D(361),DN(361)
           REAL LAND
           DATA NOLD/777/,N1OLD/-2/,MOLD/-2/
           DATA LAND/9.999/
C
         XD=-.90
         IF(N.EQ.NOLD.AND.M.EQ.MOLD) GO TO 700
           XD=NOLD
C                **RESTRICTED IN FORMULATIONS SO THAT
C                **N.EQ.1 DOES NOT OCCURE.
                 N1=N-1
                 MM1=M-1
                 IF(MM1.EQ.0) MM1=360
                 IA=0
                 IB=0
                 ID =0
                 IE =0
                 ICF=0
           IF(.NOT.(N.NE.NOLD)) GO TO 55
CC               **READ FROM RANDOM ACCESS FILES ON UNITS 1AND 3
                 CALL READMS(1,XN(1), 361,N1)
                 CALL READMS(3,DN(1), 361,N1)
              IF(.NOT.(N.LT.169)) GO TO 40
                 CALL READMS(1, X(1), 361,N)
                 CALL READMS(3, D(1), 361,N)
   40            CONTINUE
C             ENDIF
   55            CONTINUE
C          ENDIF
                 DMN= D(M)
                 DM1N=D(MM1)
                 DMN1=DN(M)
                 DM1N1=DN(MM1)
                 IF(.NOT.(N.EQ.169)) GO TO 70
                       DM1N=999.9
                       DMN=999.9
                       X(M)=9.999
                       X(MM1)=9.999
   70                  CONTINUE
C                ENDIF
                 IF(.NOT.(XN(M).EQ.LAND)) GO TO 100
                       T=0.
                       IA=1
  100                  CONTINUE
C                ENDIF
```

```
SUBROUTINE GTD        73/74   OPT=1                 FTN 4.6+433       01/18/83  11.40.06      PAGE     2

                        IF(.NOT.(X(M).EQ.LAND)) GO TO 200
                              IB=1
                              T=1.
              200             CONTINUE
          C              ENDIF
                         IF(IA+IB .EQ.2) PSI=1.
                        IF(.NOT.(XN(MM1).EQ.LAND)) GO TO 300
                              ID=1
                              TB=0.
              300             CONTINUE
          C              ENDIF
                        IF(.NOT.(X(MM1).EQ.LAND)) GO TO 400
                              IE=1
                              TB=1.
              400             CONTINUE
          C              ENDIF
                         IF( ID+IE.EQ.2) PSI=0.
                         IF( IA+IB+ID+IE.EQ.4) ICF=1
                         NOLD=N
                         N1OLD=N1
                         MOLD=M
              700    CONTINUE
          C       ENDIF
                         RETURN
                         END
```

```
    SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
   3  GTD              1           81

VARIABLES     SN  TYPE            RELOCATION
  211  D          REAL       ARRAY                REFS        13       37       42       43
    0  DMN        REAL                 F.P.    DEFINED         1       42       48
    0  DMN1       REAL                 F.P.    DEFINED         1       44
    0  DM1N       REAL                 F.P.    DEFINED         1       43       47
    0  DM1N1      REAL                 F.P.    DEFINED         1       45
  762  DN         REAL       ARRAY                REFS        13       34       44       45
  205  IA         INTEGER                         REFS        63       75  DEFINED       26       55
  206  IB         INTEGER                         REFS        63       75  DEFINED       27       59
    0  ICF        INTEGER              F.P.    DEFINED         1       30       75
  207  ID         INTEGER                         REFS        74       75  DEFINED       28       65
  210  IE         INTEGER                         REFS        74       75  DEFINED       29       70
  173  LAND       REAL                            REFS        14       53       58       64       69
                                               DEFINED        16
    0  M          INTEGER              F.P.       REFS        19       24       42       44       49       53       58
                                                    78   DEFINED        1
    0  MM1        INTEGER              F.P.       REFS        25       43       45       50       64       69
                                               DEFINED         1       24       25
  172  MOLD       INTEGER                         REFS        19  DEFINED       15       78
    0  N          INTEGER              F.P.       REFS        19       23       31       35       36       37       46
                                                    76   DEFINED        1
  170  NOLD       INTEGER                         REFS        19       20       31  DEFINED       15       76
```

```
      SUBROUTINE GTD        73/74   OPT=1                      FTN 4.6+433       01/18/83  11.40.06       PAGE      3

VARIABLES      SN  TYPE            RELOCATION
  204  N1          INTEGER                          REFS        33        34        77   DEFINED        23
  171  N1OLD       INTEGER                        DEFINED       15        77
    0  PSI         REAL                 F.P.      DEFINED        1        63        74
    0  T           REAL                 F.P.      DEFINED        1        54        60
    0  TB          REAL                 F.P.      DEFINED        1        66        71
    0  X           REAL        ARRAY    F.P.        REFS        13        36        58        69   DEFINED      1      49
                                                     50
    0  XD          REAL                 F.P.      DEFINED        1        18        20
    0  XN          REAL        ARRAY    F.P.        REFS        13        33        53        64   DEFINED      1

EXTERNALS          TYPE    ARGS        REFERENCES
      READMS                4             33        34        36        37

STATEMENT LABELS              DEF LINE   REFERENCES
   45  40                        38          35
   45  55                        40          31
   64  70                        51          46
   73  100                       56          53
  102  200                       61          58
  115  300                       67          64
  124  400                       72          69
  143  700                       79          19

STATISTICS
  PROGRAM LENGTH                1533B       859
```

```
SUBROUTINE JUMPS      74/74   OPT=1                       FTN 4.6+433       05/06/83  09.46.53       PAGE      1

   1                     SUBROUTINE JUMPS( DMN, DM1N, DMN1, DM1N1    )
               C         CALLED BY
               C              SSTGTD
               C         **TEST FOR 360 DEGREES PHASE JUMPS
   5                     D1=DMN1 -DMN
                         D2=DM1N1-DMN
                         D3=DM1N -DMN
                         D4=DM1N1-DMN1
                         D5=DM1N -DMN1
  10                     D6=DM1N -DM1N1
                         IF(D1.GT. 180.0) DMN1 =DMN1 -360.0
                         IF(D1.LT.-180.0) DMN  =DMN  -360.0
                         IF(D2.GT. 180.0) DM1N1=DM1N1-360.0
                         IF(D2.LT.-180.0) DMN  =DMN  -360.0
  15                     IF(D3.GT. 180.0) DM1N =DM1N -360.0
                         IF(D3.LT.-180.0) DMN  =DMN  -360.0
                         IF(D4.GT. 180.0) DM1N1=DM1N1-360.0
                         IF(D4.LT.-180.0) DMN1 =DMN1 -360.0
                         IF(D5.GT. 180.0) DM1N =DM1N -360.0
  20                     IF(D5.LT.-180.0) DMN1 =DMN1 -360.0
                         IF(D6.GT. 180.0) DM1N =DM1N -360.0
                         IF(D6.LT.-180.0) DM1N1=DM1N1-360.0
                         RETURN
                         END


   SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE     REFERENCES
    3  JUMPS          1          23

VARIABLES     SN  TYPE            RELOCATION
    O  DMN        REAL                  F.P.      REFS        5      6        7      12      14      16
                                               DEFINED        1     12       14      16
    O  DMN1       REAL                  F.P.      REFS        5      8        9      11      18      20
                                               DEFINED        1     11       18      20
    O  DM1N       REAL                  F.P.      REFS        7      9       10      15      19      21
                                               DEFINED        1     15       19      21
    O  DM1N1      REAL                  F.P.      REFS        6      8       10      13      17      22
                                               DEFINED        1     13       17      22
  102  D1         REAL                            REFS       11     12  DEFINED       5
  103  D2         REAL                            REFS       13     14  DEFINED       6
  104  D3         REAL                            REFS       15     16  DEFINED       7
  105  D4         REAL                            REFS       17     18  DEFINED       8
  106  D5         REAL                            REFS       19     2C  DEFINED       9
  107  D6         REAL                            REFS       21     22  DEFINED      10

STATISTICS
  PROGRAM LENGTH              110B       72
```

```
SUBROUTINE LATLON     73/74   OPT=1                         FTN 4.6+433      01/18/83  11.40.06       PAGE     1

                     SUBROUTINE LATLON
                G                         ( K, J , ISST
                Y                         , PHI, LAM, M , N, T, TB
                B                         , PSI )
            C    AUTHOR
            C         L. T. SZETO
            C    LANGUAGE
            C         CDC FORTRAN EXTENDED
            C         CALLED BY
            C              SSTGTD
            C
                     REAL LAM, LAMBAR
                     REAL LAT(384), LONG(384)
                     IF(.NOT.((K.EQ.1).AND.(J.EQ.1))) GO TO 200
                          READ(ISST) (LAT(I),I=1,384)
                          READ(ISST)(LONG(I),I=1,384)
              200         CONTINUE
            C        ENDIF
                     PHI=LAT(J)
                     LAM=LONG(J)
            C        LATITUDE AND LONGITUDE(PHI,LAM ) FROM SST ARE IN DEGREES
                     LAMBAR= 1.5-K+ LAM
                     IF(LAMBAR.LT.0.0) LAMBAR= LAMBAR+360.
                     IF(LAMBAR.GT.360.) LAMBAR= LAMBAR-360.
                     M= LAMBAR+1
                     P9=90.5-PHI
                     N=P9+1.
                     PSI= M- LAMBAR
                     T=N-P9
                     TB=T
                     RETURN
                     END


      SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
    3  LATLON         1            31

VARIABLES      SN  TYPE          RELOCATION
   63  I           INTEGER                         REFS       15       16    DEFINED       15          16
    O  ISST        INTEGER               F.P.   DEFINED        1   I/O REFS       15       16
    O  J           INTEGER               F.P.      REFS       14       19         20   DEFINED           1
    O  K           INTEGER               F.P.      REFS       14       22    DEFINED        1
    O  LAM         REAL                  F.P.      REFS       12       22    DEFINED        1          20
   62  LAMBAR      REAL                            REFS       12     2*23       2*24       25          28
                                                DEFINED       22       23         24
   65  LAT         REAL        ARRAY               REFS       13       19    DEFINED       15
  665  LONG        REAL        ARRAY               REFS       13       20    DEFINED       16
    O  M           INTEGER               F.P.      REFS       28  DEFINED          1       25
    O  N           INTEGER               F.P.      REFS       29  DEFINED          1       27
    O  PHI         REAL                  F.P.      REFS       26  DEFINED          1       19
    O  PSI         REAL                  F.P.   DEFINED        1       28
   64  P9          REAL                            REFS       27       29    DEFINED       26
```

```
      SUBROUTINE LATLON      73/74    OPT=1                        FTN 4.6+433        01/18/83  11.40.06        PAGE      2

VARIABLES       SN  TYPE            RELOCATION
    O  T            REAL                 F.P.       REFS       30    DEFINED        1         29
    O  TB           REAL                 F.P.    DEFINED        1         30
       VARIABLES USED AS FILE NAMES, SEE ABOVE

STATEMENT LABELS              DEF LINE   REFERENCES
   15  200                        17         14

STATISTICS
  PROGRAM LENGTH                14658      821
```

APPENDIX C

STT PROGRAM USER'S GUIDE AND PROGRAM LISTING

APPENDIX C

1. STT PROGRAM USER'S GUIDE

The Satellite Track Tide (STT) program computes instantaneous geocentric tides at equidistant points along a given Constrained Satellite Track (CST).

The following program listing shows the STT (program) subroutine written in CDC Fortran Extended for the CDC 6700 computer under the SCOPE 3.4 operating system.

The STT subroutine is called with the following statement:

```
CALL STT  (MODES, YEAR, DAY, TIME1, NTOTAL, IUNIT, ISST,
           CSTLAT, CSTLON, ELONA, ELONB, ETIMEA, ETIMEB,
           TIDE, DT, NPTS, ISTOP)
```

where

MODES = the number of tidal modes to process

YEAR = year ⩾ 1975

DAY = day of YEAR, example: February 1, 1978, DAY = 32

TIME1 = time (in sec) of 1st point of the CST to be processed relative to Greenwich midnight of DAY

NTOTAL = number of points on the CST to be processed

IUNIT = beginning unit number of (2 x MODES) consecutive units to which the SSTGTD files are attached

ISST = unit number to which the SST file is attached

CSTLAT = array containing latitudes of the 1st 2 CST points in degrees

CSTLON = array containing longitudes (EAST) of the 1st 2 CST points in degrees

ELONA = } equator crossing longitudes (in deg) corresponding to the 2
ELONB = } consecutive ascending modes of the track containing the CST

ETIMEA = } equator crossing times (in sec) relative to Greenwich midnight
ETIMEB = } of DAY, (DAY-1), or (DAY+1) for ETIMEA belonging to ELONA and ETIMEB belonging to ELONB

TIDE = array containing the generated tide values

DT = time in sec between consecutive points of the CST

NPTS = number of tide values returned by STT in TIDE(1) through TIDE (NPTS), $1 \leq NPTS \leq 100$

ISTOP = flag, if ISTOP = 0, the last set of tide values have been generated for the given CST.

For each CST track to be processed, the STT subroutine (program) is called repeated until a zero is returned for the ISTOP variable. For each successive return from STT, NPTS indicates the number of successive tide values generated and stored in the TIDE array. ($1 \leq NPTS \leq 100$) Also, NPTS *must* be set to −1 before the first call to STT for each track. The BUFFER IN statement in STT bring in data files (SSTGTD) that are in binary form. The SSTGTD magnetic tapes are in coded form as described in Section 4. The SST data file is also described in Section 4. The following shows how the SSTGTD files are attached.

ATTACH, TAPE ℓ, $\xi^{i=1}_{j,k}$

ATTACH, TAPE ℓ+1, $\delta^{i=1}_{j,k}$

ATTACH, TAPE ℓ+2, $\xi^{2}_{j,k}$

ATTACH, TAPE ℓ+3, $\delta^{2}_{j,k}$

⋮

ATTACH, TAPE ℓ+21, $\xi^{11}_{j,k}$

ATTACH, TAPE ℓ+22, $\delta^{11}_{j,k}$

i = 1,2, ..., 11 (tidal model)
j = 1,2, ..., 383 (SST points)
k = 1,2, ..., 360 (SST number)
SSTGTD files, see Section 4

2. STT PROGRAM LISTING

```
SUBROUTINE STT        74/74   OPT=0 TRACE                FTN 4.6+433        01/21/83  16.18.59        PAGE     1

                SUBROUTINE STT
          G                    (MODES,YEAR,DAY,TIME1,NTOTAL,IUNIT,ISST
          G                    .CSTLAT, CSTLON, ELONA, ELONB,ETIMEA,ETIMEB
          Y                    , TIDE
          B                    , DT,NPTS,NMINUS)
      C         CALLS TO
      C              CONST
      C              ECROSS
      C              INTRP1
      C              INTRP2

                DIMENSION TIDE(100), TIDEB(383)
                DIMENSION CSTLON(4), CSTLAT(4)
                DIMENSION SSTLAT(383), SSTLON(383)
                DIMENSION ASTROB(11), FREQB(11)
                INTEGER YEAR, DAY
                DATA NCASE/0/

                IF(.NOT.(NPTS.LT.0)) GO TO 6080
      C              ..PERFORM THE FOLLOWING IF THIS IS
      C              THE 1ST CALL TO STT FOR THE CURRENT
      C              CST(CONSTRAINED SATELLITE TRACK)THAT
      C              IS BEING PROCESSED.
                     NCASE=0
                     REWIND ISST
      C              ..READ FROM THE SST FILE.
                     READ(ISST) (SSTLAT(I),I=1,383),SSTTS
                     READ(ISST) (SSTLON(I),I=1,383),HAT
                     CALL ECROSS
          G                     (CSTLAT,CSTLON, DAY,SSTTS,HAT
          G                       .ETIMEA,ETIMEB,ELONA,ELONB,TIME1,NTOTAL
          Y                      , ETIME,ELONG, K, TAU1, RLATD,JCAP,MCAP,TAUN
          B                      , DT              )
                     CALL CONST
          G                    (DAY,YEAR,      ETIME,      SSTTS
          Y                      , ASTROB,FREQB,       DTAUT )

      C              ..THE 1ST ROUGH INTERPOLATION OF TIDAL
      C              HEIGHTS(TIDEB) WITH SST-SPACING ALONG
      C              THE CST THAT IS BEING PROCESSED.
                     CALL INTRP1
          G                      ( MODES,JCAP,K,MCAP,NTOTAL,RLATD
          G                      , DT, SSTTS,DTAUT,TAU1,TAUN,IUNIT
          G                      , FREQB, ASTROB
          Y                      , TIDEB               )
                     NMINUS=NTOTAL
       6080          CONTINUE
      C         ENDIF

                NPTS=100
                IF(.NOT.( NMINUS.LT.100)) GO TO 7020
                     NPTS= NMINUS
       7020          CONTINUE
      C         ENDIF

      C         ..COMPUTE INSTANTANEOUS GEOCENTRIC TIDES(TIDE)
      C         AT GIVEN CST-SPACINGS.
```

```
      SUBROUTINE STT        74/74    OPT=0 TRACE                 FTN 4.6+433         01/21/83  16.18.59        PAGE      2

                              CALL INTRP2
                          G              ( MCAP,NTOTAL, DT,SSTTS, DTAUT
   60                     G              , TAU1, NMINUS, TIDEB, NPTS
                          Y              , TIDE
                          B              , NCASE          )
                              NMINUS= NMINUS-NPTS
                              NPTOLD= NPTS
   65                         RETURN
                              END


      SYMBOLIC REFERENCE MAP (R=3)

  ENTRY POINTS       DEF LINE      REFERENCES
     4  STT              1            65

  VARIABLES       SN  TYPE            RELOCATION
   2432  ASTROB      REAL      ARRAY                REFS        15       34       41
      0  CSTLAT      REAL      ARRAY     F.P.       REFS        13       29  DEFINED        1
      0  CSTLON      REAL      ARRAY     F.P.       REFS        13       29  DEFINED        1
      0  DAY         INTEGER             F.P.       REFS        16       29       34  DEFINED        1
      0  DT          REAL                F.P.       REFS        29       41       58  DEFINED        1
    233  DTAUT       REAL                           REFS        34       41       58
      0  ELONA       REAL                F.P.       REFS        29  DEFINED        1
      0  ELONB       REAL                F.P.       REFS        29  DEFINED        1
    224  ELONG     * REAL                           REFS        29
    223  ETIME       REAL                           REFS        29       34
      0  ETIMEA      REAL                F.P.       REFS        29  DEFINED        1
      0  ETIMEB      REAL                F.P.       REFS        29  DEFINED        1
   2445  FREQB       REAL      ARRAY                REFS        15       34       41
    222  HAT         REAL                           REFS        29  DEFINED       28
    220  I           INTEGER                        REFS        27       28  DEFINED       27       28
      0  ISST        INTEGER             F.P.    DEFINED         1  I/O REFS       25       27       28
      0  IUNIT       INTEGER             F.P.       REFS        41  DEFINED        1
    230  JCAP        INTEGER                        REFS        29       41
    225  K           INTEGER                        REFS        29       41
    231  MCAP        INTEGER                        REFS        29       41       58
      0  MODES       INTEGER             F.P.       REFS        41  DEFINED        1
    204  NCASE       INTEGER                        REFS        58  DEFINED       17       24
      0  NMINUS      INTEGER             F.P.       REFS        51       52       58       63  DEFINED        1       46
                                                      63
    234  NPTOLD    * INTEGER                     DEFINED        64
      0  NPTS        INTEGER             F.P.       REFS        19       58       63       64  DEFINED        1       50
                                                      52
      0  NTOTAL      INTEGER             F.P.       REFS        29       41       46       58  DEFINED        1
    227  RLATD       REAL                           REFS        29       41
   1034  SSTLAT      REAL      ARRAY                REFS        14  DEFINED       27
   1633  SSTLON      REAL      ARRAY                REFS        14  DEFINED       28
    221  SSTTS       REAL                           REFS        29       34       41       58  DEFINED       27
    232  TAUN        REAL                           REFS        29       41
    226  TAU1        REAL                           REFS        29       41       58
      0  TIDE        REAL      ARRAY     F.P.       REFS        12       58  DEFINED        1
    235  TIDEB       REAL      ARRAY                REFS        12       41       58
      0  TIME1       REAL                F.P.       REFS        29  DEFINED        1
```

```
      SUBROUTINE STT         74/74   OPT=0 TRACE                    FTN 4.6+433       01/21/83  16.18.59       PAGE     3

VARIABLES     SN  TYPE            RELOCATION
    0  YEAR      INTEGER               F.P.        REFS       16        34    DEFINED         1
      VARIABLES USED AS FILE NAMES, SEE ABOVE

EXTERNALS           TYPE   ARGS        REFERENCES
      CONST                  7              34
      ECROSS                20              29
      INTRP1                15              41
      INTRP2                11              58

STATEMENT LABELS             DEF LINE   REFERENCES
   63  6080                     47          19
   74  7020                     53          51

STATISTICS
  PROGRAM LENGTH              2460B     1328
```

```
SUBROUTINE CONST      74/74   OPT=0 TRACE                FTN 4.6+433        01/21/83  16.18.59        PAGE    1

                SUBROUTINE CONST
           G                       (DAY,YEAR,       ETIME,        SSTTS
           Y                        , ASTROB, FREQB,       DTAUT       )
        C       CALLED BY
        C            STT

                DIMENSION ASTRO (11), FREQ (11)
           1    ,          ASTROB(11), FREQB(11)
                INTEGER DAY,YEAR
                DATA PI/3.1415926535898/
                DATA ( FREQ= 1.40519E-4, 1.45444E-4, 0.72921E-4
           1    ,0.67598E-4, 1.37880E-4, 0.72523E-4, 1.45842E-4
           2    ,0.64959E-4, 0.53234E-5, 0.26392E-5, 0.39821E-6)
                DTR= PI/180.
                DTAUT= 1./SSTTS
                D=DAY+365*(YEAR-1975)+ INT((YEAR-1973)/4.0)
                T=(27392.500528+1.0000000356*D)/ 36525.
                T2=T*T
                T3=T2*T

        C       **COMPUTE MEAN LONGITUDES OF SUN,MOON, AND LUNAR
        C       PERIGEE AT GREENWICH MIDNIGHT.(DEGREES)
                HO=279.69668+ 36000.768925485*T+(3.03E-4*T2)
                SO=270.434358+481267.88314137*T-0.001133*T2+
           1       (1.9E-6*T3)
                PO=334.329653+4069.0340329575*T-0.010325*T2
           1       -(1.2E-5*T3)
                HO2=HO+HO
                SO2=SO+SO
                SO3=SO2+SO

        C       **COMPUTE ASTRONOMICAL ARGUMENTS ,ASTRO()IN DEGREES,
        C       OF THE PARTIAL TIDES.
                ASTRO( 1)=HO2-SO2
                ASTRO( 2)=0.
                ASTRO( 3)=HO+90.
                ASTRO( 4)=HO-SO2-90.
                ASTRO( 5)=HO2-SO3+PO
                ASTRO( 6)=-HO-90.
                ASTRO( 7)=HO2
                ASTRO( 8)=HO-SO3+PO-90.
                ASTRO( 9)=SO2
                ASTRO(10)=SO-PO
                ASTRO(11)=HO2
                DO 6060 I=1,11
                     FREQB(I)= FREQ(I)*SSTTS
                     ASTROB(I)=FREQ(I)*ETIME- 2.0*FREQB(I)+ASTRO(I)*DTR
         6060        CONTINUE
        C       ENDDO
                RETURN
                END
```

```
      SUBROUTINE CONST      74/74   OPT=0 TRACE                     FTN 4.6+433       01/21/83  16.18.59       PAGE      2

      SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE     REFERENCES
    4  CONST           1        50

VARIABLES      SN  TYPE           RELOCATION
   220  ASTRO     REAL       ARRAY                 REFS         7        47   DEFINED        34        35        36        37
                                                    38         39        40        41        42        43        44
     0  ASTROB    REAL       ARRAY      F.P.       REFS         7   DEFINED         1        47
   205  D         REAL                             REFS        17   DEFINED        16
     0  DAY       INTEGER               F.P.       REFS         9        16   DEFINED         1
     0  DTAUT     REAL                  F.P.    DEFINED         1        15
   204  DTR       REAL                             REFS        47   DEFINED        14
     0  ETIME     REAL                  F.P.       REFS        47   DEFINED         1
   233  FREQ      REAL       ARRAY                 REFS         7        46        47   DEFINED        11
     0  FREQB     REAL       ARRAY      F.P.       REFS         7        47   DEFINED         1        46
   211  HO        REAL                             REFS      2*28        36        37        39        41
                                                DEFINED        23
   214  HO2       REAL                             REFS        34        38        40        44   DEFINED        28
   217  I         INTEGER                          REFS      2*46      4*47   DEFINED        45
   160  PI        REAL                             REFS        14   DEFINED        10
   213  PO        REAL                             REFS        38        41        43   DEFINED        26
     0  SSTTS     REAL                  F.P.       REFS        15        46   DEFINED         1
   212  SO        REAL                             REFS      2*29        30        43   DEFINED        24
   215  SO2       REAL                             REFS        30        34        37        42   DEFINED        29
   216  SO3       REAL                             REFS        38        41   DEFINED        30
   206  T         REAL                             REFS      2*18        19        23        24        26
                                                DEFINED        17
   207  T2        REAL                             REFS        19        23        24        26   DEFINED        18
   210  T3        REAL                             REFS        24        26   DEFINED        19
     0  YEAR      INTEGER               F.P.       REFS         9      2*16   DEFINED         1

INLINE FUNCTIONS   TYPE    ARGS         DEF LINE   REFERENCES
       INT         INTEGER   1  INTRIN                 16

STATEMENT LABELS              DEF LINE    REFERENCES
    0  6060                      48          45

LOOPS   LABEL    INDEX     FROM-TO     LENGTH     PROPERTIES
  142   6060     I           45 48        14B         OPT

STATISTICS
  PROGRAM LENGTH                265B      181
```

```
              SUBROUTINE ECROSS
     G                   (CSTLAT,CSTLON, D, SSTTS, HAT
     G                   ,ETIMEA,ETIMEB,ELONA,ELONB,TIME1,NTOTAL
     Y                   ,ETIME, ELONG, K, TAU1, RLATD,JCAP,MCAP,TAUN
     B                   , DT            )
C             CALLED BY
C                  STT

              INTEGER D
                 REAL   CSTLAT(  4), CSTLON(  4)
              RL1=360.-ELONB+ELONA
              IF( RL1.LT.360.) RL1=RL1+360.
              THAT= ETIMEB- ETIMEA
              IF( THAT.LT.O.) THAT=THAT+86400
              TAUHAT= 380.*SSTTS
              TAU1= TIME1- ETIMEA
              T3= 3.* THAT
              IF(.NOT.( TAU1.GT.T3)) GO TO 1020
                   TAU1= TAU1-86400.
                   TIME1=TIME1-86400.
                   D=D+1
 1020              CONTINUE
C             ENDIF
              IF(.NOT.( TAU1.LT.-T3)) GO TO 1030
                   TAU1= TAU1+86400.
                   TIME1= TIME1+86400.
                   D=D-1
 1030              CONTINUE
C             ENDIF
              SSTTS2= SSTTS/2.
              TAUN=TAU1+ (NTOTAL-1)*DT
C
C             ..COMPUTE LONGITUDE(ELONG) AT WHICH THE CST CROSSES
C             LATITUDE LINE SSTLAT(JCAP)
C             ..COMPUTE THE TIME(ETIME) AT WHICH THE CST CROSSES
C             LATITUDE LINE SSTLAT(JCAP)
              IF(.NOT.((TAU1.LT.-SSTTS2).OR.(TAUN-TAUHAT.GT.SSTTS2)))GOTO1070
                   STOP "STOPPED IN ECROSS.CHECK TRACK DATA"
 1070              CONTINUE
                   HH= TAUHAT/THAT
                   DT= DT*HH
                   ETIME= ETIMEA
                   TAU1= TAU1+HH
                   ELONG=ELONA+ .5*(RL1- HAT)
                   IF(ELONG.LT.O.)ELONG=ELONG+360.
                   IF(ELONG.GT.360.) ELONG=ELONG-360.
C             ENDIF
              IF(.NOT.(ABS(TAU1).LT.SSTTS)) GO TO 1090
                   DL1= CSTLON(1)-CSTLON(2)
                   IF( DL1.LT.O.) DL1=DL1+360.
                   PHI= CSTLAT(1)/( CSTLAT(2)-CSTLAT(1))
                   DL= ELONG-CSTLON(1)
                   IF(DL.LT.-10.) DL=DL+360.
                   DLP= PHI*DL1
                   TAU1P=PHI*DT
                 IF(.NOT.(.NOT.((ABS(TAU1-TAU1P).GT.(.4*SSTTS)).OR.
     1             (ABS(DL-DLP).GT.O.4))))GOTO 3030
```

```
SUBROUTINE ECROSS     74/74   OPT=0 TRACE                 FTN 4.6+433         01/21/83  16.18.59        PAGE      2

                            ETIME=ETIME+ TAU1- TAU1P
                            TAU1= TAU1P
                            ELONG= CSTLON(1)+ DLP
                            IF(ELONG.LT.0.) ELONG=ELONG+360.
                            IF(ELONG.GT.360.)ELONG=ELONG-360.
                            GO TO 3040
                C         ELSE
                  3030      CONTINUE
                            STOP "STOPPED IN ECROSS, CHECK TRACK DATA"
                  3040      CONTINUE
                C         ENDIF
                  1090      CONTINUE
                C       ENDIF
                C       **COMPUTE K-BRACKETS OF THE CST
                        EL=361.-ELONG
                        K= INT(EL)
                        RLATD= EL-K
                        IF( K.EQ.361) K=1
                        JCAP= INT(2.+ TAU1/SSTTS)
                        MCAP= INT(4.- JCAP+ TAUN/SSTTS)
                        TAU1= TAU1-(JCAP-2)*SSTTS
                        RETURN
                        END


    SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
   4  ECROSS            1          79

VARIABLES       SN   TYPE            RELOCATION
     0  CSTLAT       REAL        ARRAY      F.P.        REFS        10      3*51    DEFINED        1
     0  CSTLON       REAL        ARRAY      F.P.        REFS        10      2*49       52         60    DEFINED         1
     0  D            INTEGER                F.P.        REFS         9        21       27    DEFINED         1        21        27
   322  DL           REAL                               REFS      2*53        56   DEFINED        52        53
   323  DLP          REAL                               REFS        56        60   DEFINED        54
   320  DL1          REAL                               REFS      2*50        54   DEFINED        49        50
     0  DT           REAL                   F.P.        REFS        31        41       55    DEFINED         1        41
   325  EL           REAL                               REFS        73        74   DEFINED        72
     0  ELONA        REAL                   F.P.        REFS        11        44   DEFINED         1
     0  ELONB        REAL                   F.P.        REFS        11   DEFINED        1
     0  ELONG        REAL                   F.P.        REFS      2*45      2*46       52       2*61      2*62        72
                                                     DEFINED         1        44       45         46        60        61        62
     0  ETIME        REAL                   F.P.        REFS        58   DEFINED        1         42        58
     0  ETIMEA       REAL                   F.P.        REFS        13        16       42    DEFINED         1
     0  ETIMEB       REAL                   F.P.        REFS        13   DEFINED        1
     0  HAT          REAL                   F.P.        REFS        44   DEFINED        1
   317  HH           REAL                               REFS        41        43   DEFINED        40
     0  JCAP         INTEGER                F.P.        REFS        77        78   DEFINED         1        76
     0  K            INTEGER                F.P.        REFS        74        75   DEFINED         1        73        75
     0  MCAP         INTEGER                F.P.     DEFINED         1        77
     0  NTOTAL       INTEGER                F.P.        REFS        31   DEFINED        1
   321  PHI          REAL                               REFS        54        55   DEFINED        51
     0  RLATD        REAL                   F.P.     DEFINED         1        74
```

```
    SUBROUTINE ECROSS        74/74    OPT=O TRACE                      FTN 4.6+433       01/21/83  16.18.59        PAGE      3

VARIABLES      SN  TYPE             RELOCATION
  312  RL1         REAL                          REFS         2*12       44    DEFINED       11        12
    O  SSTTS       REAL                F.P.      REFS           15       30         48       56        76        77        78
                                              DEFINED            1
                                                 REFS         2*37   DEFINED        30
  316  SSTTS2      REAL                          REFS           37       40    DEFINED       15
  314  TAUHAT      REAL                          REFS           37       77    DEFINED        1        31
    O  TAUN        REAL                F.P.      REFS           18       19         24       25        31        37        43
    O  TAU1        REAL                F.P.      REFS           18       19         24       25        31        37        43
                                                   48           56       58         76       78   DEFINED         1        16
                                                   19           25       43         59       78
  324  TAU1P       REAL                          REFS           56       58         59  DEFINED        55
  313  THAT        REAL                          REFS         2*14       17         40  DEFINED        13        14
    O  TIME1       REAL                F.P.      REFS           16       20         26  DEFINED         1        20        26
  315  T3          REAL                          REFS           18       24    DEFINED       17

INLINE FUNCTIONS   TYPE    ARGS          DEF LINE  REFERENCES
       ABS         REAL      1  INTRIN                  48        2*56
       INT         INTEGER   1  INTRIN                  73          76         77

STATEMENT LABELS               DEF LINE    REFERENCES
   54  1020                       22           18
   71  1030                       28           24
  113  1070                       39           37
  237  1090                       69           48
  233  3030                       65           56
  236  3040                       67           63

STATISTICS
  PROGRAM LENGTH                3408          224
```

```
SUBROUTINE INOUT       74/74   OPT=0 TRACE                    FTN 4.6+433        01/21/83  16.18.59       PAGE      1

   1                 SUBROUTINE INOUT( IN, OUT ,X, D, II)
             C       CALLED BY
             C           SSTGTD
                     DIMENSION X(II) ,D(II)
   5                 INTEGER OUT,OT1
                     IF(.NOT. (IN.NE.0)) GO TO 22
                         BUFFER  IN( IN,1) ( X(1), X( II))
                         IN1= IN+1
                         IF(UNIT( IN)) 20,12,13
  10           20        CONTINUE
                         BUFFER  IN(IN1,1) ( D(1), D( II))
                         IF(UNIT(IN1)) 22,12,13
               22        CONTINUE
             C       ENDIF
  15         C
                     IF(.NOT.(OUT.NE.0)) GO TO 30
                         BUFFER OUT(OUT,1) ( X(1), X( II))
                         IF(UNIT(OUT)) 30,12,13
               30        CONTINUE
  20         C       ENDIF
                     RETURN
               12    STOP "12,SUBROUTINE INOUT"
               13    STOP "13,SUBROUTINE INOUT"
                     END


     SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
   4  INOUT           1            21

VARIABLES      SN  TYPE            RELOCATION
   0  D            REAL      ARRAY     F.P.        REFS       4   DEFINED       1      2*11
   0  II           INTEGER             F.P.        REFS     2*4        7       11        17   DEFINED       1
   0  IN           INTEGER             F.P.        REFS       6        8        9   DEFINED       1
                                                I/O REFS      7
 104  IN1          INTEGER                         REFS      12   DEFINED       8   I/O REFS     11
 103  OT1        * INTEGER   *UNDEF                REFS       5
   0  OUT          INTEGER             F.P.        REFS       5       16       18   DEFINED       1
                                                I/O REFS     17
   0  X            REAL      ARRAY     F.P.        REFS       4     2*17  DEFINED        1       2*7
      VARIABLES USED AS FILE NAMES, SEE ABOVE

EXTERNALS          TYPE   ARGS        REFERENCES
     UNIT          REAL     1              9         12        18

STATEMENT LABELS               DEF LINE    REFERENCES
  55  12                          22           9         12        18
  57  13                          23           9         12        18
   0  20           INACTIVE       10           9
  36  22                          13           6         12
  53  30                          19          16         18
```

```
      SUBROUTINE INOUT      74/74    OPT=0 TRACE               FTN 4.6+433       01/21/83  16.18.59       PAGE      2

 STATISTICS
   PROGRAM LENGTH             113B       75
```

```
                  SUBROUTINE INTRP1
          G                         (  MODES, JCAP, K, MCAP, NTOTAL, RLATD
          G                         , DT, SSTTS, DTAUT, TAU1, TAUN,IUNIT
          G                         .                FREQB, ASTROB
          Y                         , TIDEB                )
        C         CALLED BY
        C              STT
        C         CALLS TO
        C              SR
        C              SSTGTD

                  DIMENSION FREQB(11), ASTROB(11),TIDEB(383)
                  DIMENSION X1(384), X2(384), D1(384), D2(384)
                  DATA PI/3.14159265/, PIPI/6.28318531/
                  DATA KOLD/-999/, JCAPO/-999/

                  J1Z383= 383-JCAP+1
        C         **OBTAIN AMPLITUDES(   ) AND PHASES(   )
        C         WHICH ENCLOSES THE CST TO BE PROCESSED
        C         **IF NOT 1ST CALL TO INTRP1
                  IF(.NOT.(KOLD.NE.-999)) GO TO 1065
        C              **RESTORE TIDEB() VALUES, IF POSSIBLE
                       IF(.NOT.(K.EQ.KOLD. AND .JCAP.GE.JCAPO)) GO TO 1060
                            ISR=2
                            CALL SR
          G                         ( ISR, JCAP, MCAP
          B                         , TIDEB, X1                 )
         1060               CONTINUE
        C              ENDIF
         1065          CONTINUE
        C         ENDIF
        C
                  IF(.NOT.((K.EQ.KOLD.AND.(JCAP.LT.JCAPO)).OR.K.NE.
          *            KOLD)) GO TO 6020
                       CALL MOVE(O.,TIDEB(1),383)
                       DO 6010 I=1, MODES
                            J=JCAP
                            CALL SSTGTD
          G                              ( K, IUNIT, I,KOLD
          Y                              , X1,X2, D1, D2              )
        C                   **D1 AND D2 VALUES ARE IN RADIANS
        C
        C                   ..COMPUTE THE 1ST ROUGH TIDAL HEIGHTS(TIDEB)
        C                   WITH SST-SPACING ALONG THE CST BY
        C                   INTERPOLATING BETWEEN THE 2 SSTGTD TRACKS
        C                   THAT BOUND THE CST.
                            DO 5070 M=1,J1Z383
        C                        **CHECK FOR LAND PTS.
                                 RL2= RLATD
                                 RL1=1.
                                 IF(.NOT.(X1(J).LE.O.)) GO TO 2050
                                      RL2=1.
         2050                         CONTINUE
        C                        ENDIF
                                 IF(.NOT.(X2(J).GT.O.)) GOTO 2055
                                      RL1=1.-RLATD
         2055                         CONTINUE
```

```
          C                 ENDIF
                            XM=RL1*X1(J)+ RL2*X2(J)
          C                 **D1 AND D2 VALUES ARE IN RADIANS
                            D1J=D1(J)
                            D2J=D2(J)
                            DMD=D1J-D2J
                            IF(DMD.GT.PI) D2J=D2J+PIPI
                            IF(DMD.LT.-PI)D1J=D1J+PIPI
                            DM=RL1*D1J+ RL2*D2J
                            IF(.NOT.(I.EQ.2)) GO TO 3040
                                 TIDEB(M)=TIDEB(M)+ XM*0.28
               1                 *COS(FREQB(7)*J+ ASTROB(7)-
               2                 (DM-0.0349))
                                 GO TO 3050
          C                 ELSE
           3040                  TIDEB(M)=TIDEB(M)+ XM*
               1                 COS(FREQB(I)*J+ ASTROB(I)- DM)
           3050                  CONTINUE
          C                 ENDIF
                            J=J+1
           5070             CONTINUE
          C            ENDDO
           6010        CONTINUE
          C       ENDDO
          C       ..STORE THE 1ST ROUGH TIDAL HEIGHTS(TIDEB) IN
          C       THEIR CORRECT SST-SPACING POSITIONS.
                  ISR=1
                  CALL SR
               G         ( ISR, JCAP, MCAP
               B         , TIDEB, X1            )
           6020   CONTINUE
          C  ENDIF
             KOLD=K
             JCAPO=JCAP
             RETURN
             END


       SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
    4  INTRP1          1           92

VARIABLES      SN  TYPE            RELOCATION
    O  ASTROB      REAL       ARRAY     F.P.        REFS        12        68        73    DEFINED         1
  303  DM          REAL                             REFS        68        73   DEFINED        66
  302  DMD         REAL                             REFS        64        65   DEFINED        63
    O  DT          REAL      *UNUSED    F.P.     DEFINED         1
    O  DTAUT       REAL      *UNUSED    F.P.     DEFINED         1
 1704  D1          REAL       ARRAY                 REFS        13        38        61
  300  D1J         REAL                             REFS        63        65        66    DEFINED        61        65
 2504  D2          REAL       ARRAY                 REFS        13        38        62
  301  D2J         REAL                             REFS        63        64        66    DEFINED        62        64
    O  FREQB       REAL       ARRAY     F.P.        REFS        12        68        73    DEFINED         1
```

```
     SUBROUTINE INTRP1      74/74   OPT=0 TRACE                  FTN 4.6+433        01/21/83  16.18.59       PAGE      3

VARIABLES      SN  TYPE            RELOCATION
  272  I           INTEGER                          REFS         38        67       2*73   DEFINED       36
  271  ISR         INTEGER                          REF.         25        85    DEFINED        24       84
    0  IUNIT       INTEGER              F.P.        REFS         38   DEFINED          1
  273  J           INTEGER                          REFS         51        55       2*59        61       62        68        73
                                                      77    DEFINED        37         77
    0  JCAP        INTEGER              F.P.        REFS         17        23         25        33       37        85        91
                                                  DEFINED         1
  262  JCAPO       INTEGER                          REFS         23        33    DEFINED        15       91
  270  J1Z383      INTEGER                          REFS         47   DEFINED         17
    0  K           INTEGER              F.P.        REFS         23      2*33         38        90  DEFINED         1
  261  KOLD        INTEGER                          REFS         21        23       2*33        38  DEFINED        15        90
  274  M           INTEGER                          REFS       2*68      2*73    DEFINED        47
    0  MCAP        INTEGER              F.P.        REFS         25        85    DEFINED         1
    0  MODES       INTEGER              F.P.        REFS         36   DEFINED          1
    0  NTOTAL      INTEGER   *UNUSED    F.P.      DEFINED         1
  257  PI          REAL                             REFS         64        65    DEFINED        14
  260  PIPI        REAL                             REFS         64        65    DEFINED        14
    0  RLATD       REAL                 F.P.        REFS         49        56    DEFINED         1
  276  RL1         REAL                             REFS         59        66    DEFINED        50       56
  275  RL2         REAL                             REFS         59        66    DEFINED        49       52
    0  SSTTS       REAL      *UNUSED    F.P.      DEFINED         1
    0  TAUN        REAL      *UNUSED    F.P.      DEFINED         1
    0  TAU1        REAL      *UNUSED    F.P.      DEFINED         1
    0  TIDEB       REAL       ARRAY     F.P.        REFS         12        25         35        68       73        85
                                                  DEFINED         1        68         73
  277  XM          REAL                             REFS         68        73    DEFINED        59
  304  X1          REAL       ARRAY                 REFS         13        25         38        51       59        85
 1104  X2          REAL       ARRAY                 REFS         13        38         55        59

EXTERNALS          TYPE     ARGS       REFERENCES
       COS         REAL      1 LIBRARY     68        73
       MOVE                  3             35
       SR                    5             25        85
       SSTGTD                8             38

STATEMENT LABELS             DEF LINE    REFERENCES
   44  1060                     28           23
   45  1065                     30           21
  103  2050                     53           51
  112  2055                     57           55
  167  3040                     73           67
  202  3050                     75           71
    0  5070                     78           47
    0  6010                     80           36
  223  6020                     88           33

LOOPS  LABEL    INDEX      FROM-TO     LENGTH     PROPERTIES
   61  6010     * I         36 80       131B                 EXT REFS  NOT INNER
   71  5070     * M         47 78       116B                 EXT REFS

STATISTICS
  PROGRAM LENGTH                 3346B     1766
```

```
              SUBROUTINE INTRP2
        G                       (MCAP, NTOTAL, DT,SSTTS, DTAUT
        G                       , TAU1,NMINUS ,      TIDEB ,NPTS
        Y                       , TIDE
        B                       , NCASE            )
  C           ..INTRP2 COMPUTES INSTANTANEOUS GEOCENTRIC
  C           TIDES(TIDE) AT GIVEN CST-SPACINGS BY
  C           USING A "CUBIC-PARABOLIC SPLINE" INTERPOLATION
  C           OF THE TIDEB VALUES.

  C           CALLED BY
  C                SST
  C           CALLS TO
  C                NCASE1
  C                NCASE2
  C                NCASE3
  C                NCASE4
  C                NCASE5
              DIMENSION TIDE(100), TIDEB(383)
              LOGICAL T1,T11,T12,T111,T112,T1121,T1122
              LOGICAL T2,T21,T22,T121,T122

              IF(.NOT.(NCASE.EQ.O)) GO TO 2010
                   T1=.F.
                   T2=.F.
                   T11  =.FALSE.
                   T111 =.FALSE.
                   T112 =.FALSE.
                   T1121=.FALSE.
                   T1122=.FALSE.
                   T12  =.FALSE.
                   T121 =.FALSE.
                   T122 =.FALSE.
                   T21  =.FALSE.
                   T22  =.FALSE.
                   T1T=TIDEB(1)
                   T2T=TIDEB(2)
                   T3T=TIDEB(3)
                   T4T=TIDEB(4)
                   IF(.NOT.(MCAP.GT.2.AND.(T2T.NE.O.))) GO TO 1010
                        T1=.T.
                        GO TO 1015
  C                ELSE
   1010                 T2=.T.
   1015                 CONTINUE
  C                ENDIF
                   IF(.NOT.( T3T.NE.O.)) GO TO 1020
                        T11=.T.
                        GO TO 1025
  C                ELSE
   1020                 T12=.T.
   1025                 CONTINUE
  C                ENDIF
                   IF(.NOT.(T1T.NE.O.)) GO TO 1030
                        T111=.T.
                        T121=.T.
                        GO TO 1035
```

```
SUBROUTINE INTRP2     74/74   OPT=0 TRACE                    FTN 4.6+433        01/21/83  16.18.59        PAGE    2

          C            ELSE
           1030              T112=.T.
                             T122=.T.
           1035              CONTINUE
          C            ENDIF
                       IF(.NOT.(MCAP.GT.3.AND.(T4T.NE.0.))) GO TO 1040
                             T1121=.T.
                             GO TO 1045
          C            ELSE
           1040              T1122=.T.
           1045              CONTINUE
          C            ENDIF
                       IF(.NOT.(MCAP.LE.2.AND.T2T.NE.0.0.AND.
               *             T1T.NE.0.0)) GO TO 1050
                             T21=.T.
                             GO TO 1055
          C            ELSE
           1050              T22=.T.
           1055              CONTINUE
          C            ENDIF
                       TAU=TAU1
                       M=1
                       IF(T1.AND.T11.AND.T111) NCASE=3
                       IF(.NOT.(T1.AND.T11.AND.T112.AND. T1121))GOTO1060
                             NCASE=3
                             TAU=TAU1-DT
                             M=2
           1060              CONTINUE
          C            ENDIF
                       IF(.NOT.(T1.AND.T11.AND.T112.AND.T1122))GOTO1065
                             NCASE=2
                             TAU=TAU1-DT
                             M=2
           1065              CONTINUE
          C            ENDIF
                       IF(T1.AND.T12.AND.T121) NCASE=2
                       IF(T1.AND.T12.AND.T122) NCASE=1
                       IF(T2.AND.T21)          NCASE=2
                       IF(T2.AND.T22)          NCASE=1
           2010        CONTINUE
          C         ENDIF
                    TT1=DTAUT/2.
                    TT2=TT1+DTAUT
                    TT3=TT2+DTAUT
                       NEND=NPTS
          C         CASE ENTRY
                       GO TO( 3010, 3020, 3030, 3040, 3050)NCASE
          C            CASE 1
          C            ..CONSTANT INTERPOLATION
           3010        CALL NCASE1
               G                  ( TIDEB,       NEND
               B                  , TIDE )
                       GO TO 4020
          C            ..LINEAR INTERPOLATION
           3020        CALL NCASE2
               G                  ( TIDEB, M,    NEND, DT, DTAUT
               *                  , NTOTAL,NMINUS, TIDE, TAU  )
```

```
                   GO TO 4020
         C         ..PARABOLIC INTERPOLATION
          3030     CALL NCASE3
              G                ( TIDEB,SSTTS,NEND,DT, MCAP
              B                 , TIDE, M, TAU,NCASE )
                   GO TO 4020
         C         ..CUBIC PARABOLIC INTERPOLATION
          3040     CALL NCASE4
              G                (TIDEB, 1, 100,SSTTS, DT
              G                ,TT1,TT2, TT3, MCAP
              B                ,TIDE,M, TAU, NCASE)
                   GO TO 4020
         C         ..PARABOLIC END-POINT INTERPOLATION
          3050     CALL NCASE5
              G                (TIDEB, 1, 100
              G                ,TT1, TT2, DT
              B                , TIDE, M, TAU)
          4020     CONTINUE
         C     ENDCASE
               RETURN
               END
```

```
      SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE      REFERENCES
    4  INTRP2          1        134

VARIABLES      SN  TYPE              RELOCATION
    O  DT          REAL                    F.P.       REFS        83        89       112       117       122       128
                                                   DEFINED         1
    O  DTAUT       REAL                    F.P.       REFS        99       100       101       112   DEFINED         1
  442  M           INTEGER                            REFS       112       117       122       128   DEFINED        79        84
                                                        90
    O  MCAP        INTEGER                 F.P.       REFS        40        63        70       117       122
                                                   DEFINED         1
    O  NCASE       INTEGER                 F.P.       REFS        23       104       117       122   DEFINED         1        80
                                                        82        88        93        94        95        96
  446  NEND        INTEGER                            REFS       107       112       117   DEFINED       102
    O  NMINUS      INTEGER                 F.P.       REFS       112   DEFINED         1
    O  NPTS        INTEGER                 F.P.       REFS       102   DEFINED         1
    O  NTOTAL      INTEGER                 F.P.       REFS       112   DEFINED         1
    O  SSTTS       REAL                    F.P.       REFS       117       122   DEFINED         1
  441  TAU         REAL                               REFS       112       117       122       128   DEFINED        78        83
                                                        89
    O  TAU1        REAL                    F.P.       REFS        78        83        89   DEFINED         1
    O  TIDE        REAL          ARRAY     F.P.       REFS        19       107       112       117       122       128
                                                   DEFINED         1
    O  TIDEB       REAL          ARRAY     F.P.       REFS        19        36        37        38        39       107       112
                                                       117       122       128   DEFINED         1
  443  TT1         REAL                               REFS       100       122       128   DEFINED        99
  444  TT2         REAL                               REFS       101       122       128   DEFINED       100
  445  TT3         REAL                               REFS       122   DEFINED       101
  421  T1          LOGICAL                            REFS        20        80        81        87        93        94
```

```
      SUBROUTINE INTRP2     74/74   OPT=0 TRACE                    FTN 4.6+433       01/21/83  16.18.59       PAGE     4

VARIABLES      SN  TYPE            RELOCATION
                                                DEFINED     24        41
   435  T1T       REAL                            REFS      54        70    DEFINED       36
   422  T11       LOGICAL                         REFS      20        80         81       87    DEFINED        26        48
   424  T111      LOGICAL                         REFS      20        80    DEFINED       27         55
   425  T112      LOGICAL                         REFS      20        81         87   DEFINED        28        59
   426  T1121     LOGICAL                         REFS      20        81    DEFINED       29         64
   427  T1122     LOGICAL                         REFS      20        87    DEFINED       30         67
   423  T12       LOGICAL                         REFS      20        93         94   DEFINED        31        51
   433  T121      LOGICAL                         REFS      21        93    DEFINED       32         56
   434  T122      LOGICAL                         REFS      21        94    DEFINED       33         60
   430  T2        LOGICAL                         REFS      21        95         96   DEFINED        25        44
   436  T2T       REAL                            REFS      40        70    DEFINED       37
   431  T21       LOGICAL                         REFS      21        95    DEFINED       34         72
   432  T22       LOGICAL                         REFS      21        96    DEFINED       35         75
   437  T3T       REAL                            REFS      47   DEFINED         38
   440  T4T       REAL                            REFS      63   DEFINED         39

EXTERNALS            TYPE    ARGS         REFERENCES
         NCASE1                 3             107
         NCASE2                 9             112
         NCASE3                 9             117
         NCASE4                13             122
         NCASE5                 9             128

STATEMENT LABELS              DEF LINE    REFERENCES
    64   1010                    44          40
    66   1015                    45          42
    75   1020                    51          47
    77   1025                    52          49
   110   1030                    59          54
   114   1035                    61          57
   124   1040                    67          63
   126   1045                    68          65
   140   1050                    75          70
   142   1055                    76          73
   167   1060                    85          81
   203   1065                    91          87
   226   2010                    97          23
   254   3010                   107         104
   262   3020                   112         104
   276   3030                   117         104
   312   3040                   122         104
   326   3050                   128         104
   335   4020                   132         110        115        120        126

STATISTICS
  PROGRAM LENGTH                447B        295
```

```
SUBROUTINE NCASE1     74/74   OPT=O TRA:E                  FTN 4.6+433        01/21/83  16.18.59        PAGE     1

  1                   SUBROUTINE NCASE1
                 G                     ( TIDEB,         NEND
                 B                     , TIDE             )
              C       CALLED BY
  5           C            INTRP2
                      DIMENSION TIDE(100), TIDEB(383)
              C       **COMPUTE
                      DO 2020 N=1,NEND
                           TIDE(N)=TIDEB(1)+ TIDEB(2)
 10          2020          CONTINUE
              C       ENDDO
                      RETURN
                      END


      SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE     REFERENCES
    4  NCASE1         1          12

VARIABLES      SN  TYPE            RELOCATION
   27  N           INTEGER                          REFS          9   DEFINED        8
    0  NEND        INTEGER                 F.P.     REFS          8   DEFINED        1
    0  TIDE        REAL         ARRAY      F.P.     REFS          6   DEFINED        1         9
    0  TIDEB       REAL         ARRAY      F.P.     REFS          6        2*9   DEFINED       1

STATEMENT LABELS               DEF LINE    REFERENCES
    0  2020                       10           8

LOOPS  LABEL     INDEX       FROM-TO     LENGTH     PROPERTIES
   20  2020      N              8 10         6B      INSTACK

STATISTICS
  PROGRAM LENGTH                  36B        30
```

```
SUBROUTINE NCASE2     74/74    OPT=O TRACE                 FTN 4.6+433        01/21/83  16.18.59        PAGE     1

                     SUBROUTINE NCASE2
               G                      ( TIDEB, M,       NEND, DT, DTAUT
               G                      ,NTOTAL, NMINUS
               Y                      ,TIDE ,TAU     )
          C          ..CASE2 IS LINEAR INTERPOLATION
          C          FOR 2 OCEANIC DATA, TIDEB(M) AND
          C          TIDEB(M+1) NOT EQUAL TO 0.0

          C          CALLED BY
          C               INTRP2
                     DIMENSION TIDE(100), TIDEB(383)
                     N1=1
                     IF(.NOT.(NTOTAL.EQ.NMINUS)) GOTO 3010
                          N1=2
                          A=DTAUT*( TIDEB(M+1)- TIDEB(M))
                          B= A*DT
                          TIDE(1)= TIDEB(M)+ A*TAU
           3010           CONTINUE
          C          ENDIF
                     IF(  N1.EQ.1) NM1=100
                     IF(  N1.EQ.2) NM1=1
                     DO 3090 I=N1,NEND
                          TIDE(I)= TIDE(NM1)+B
                          NM1=I
           3090           CONTINUE
          C          ENDDO
                     RETURN
                     END


  SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE      REFERENCES
   4  NCASE2          1          27

VARIABLES      SN  TYPE            RELOCATION
   73  A           REAL                          REFS        16         17    DEFINED        15
   74  B           REAL                          REFS        23    DEFINED         16
    O  DT          REAL                 F.P.     REFS        16    DEFINED          1
    O  DTAUT       REAL                 F.P.     REFS        15    DEFINED          1
   76  I           INTEGER                       REFS        23         24    DEFINED        22
    O  M           INTEGER              F.P.     REFS      2*15         17    DEFINED         1
    O  NEND        INTEGER              F.P.     REFS        22    DEFINED          1
    O  NMINUS      INTEGER              F.P.     REFS        13    DEFINED          1
   75  NM1         INTEGER                       REFS        23    DEFINED         20         21         24
    O  NTOTAL      INTEGER              F.P.     REFS        13    DEFINED          1
   72  N1          INTEGER                       REFS        20         21         22    DEFINED        12        14
    O  TAU         REAL                 F.P.     REFS        17    DEFINED          1
    O  TIDE        REAL        ARRAY    F.P.     REFS        11         23    DEFINED          1         17        23
    O  TIDEB       REAL        ARRAY    F.P.     REFS        11       2*15         17    DEFINED          1

STATEMENT LABELS             DEF LINE    REFERENCES
   45  3010                      18          13
    O  3090                      25          22
```

```
      SUBROUTINE NCASE2     74/74    OPT=0 TRACE                 FTN 4.6+433        01/21/83  16.18.59        PAGE      2

LOOPS  LABEL     INDEX      FROM-TO     LENGTH    PROPERTIES
   57  3090      I            22 25        11B       OPT

STATISTICS
  PROGRAM LENGTH               122B       82
```

```
              SUBROUTINE NCASE3
     G                       ( TIDEB, SSTTS,  NEND, DT, MCAP
     B                       , TIDE, M, TAU,NCASE )
   C          ..CASE3 IS PARABOLIC INTERPOLATION FOR ) OCEANIC DATA NE O O
   C          CALLED BY
   C               INTRP2
   C          CALLS TO
   C               NCASE4
              REAL TIDE(100) ,TIDEB(383)
              DTAU=SSTTS
              DTAUT=1./DTAU
              TT1= DTAUT/2
              TT2= TT1*DTAUT
              TT3= TT2*DTAUT
              M1=M+1
              M2=M+2
              M3=M+3
              A=TT1*(-3.*TIDEB(M)+ 4.*TIDEB(M1)- TIDEB(M2))
              B=TT2*(TIDEB(M)-2.*TIDEB(M1)+ TIDEB(M2))
              IF(.NOT.(MCAP.LT.M3.OR.(TIDEB(M3).EQ.O.)))GOTO3050
                   DO 2050 N=1,NEND
                        TIDE(N)=(B*TAU+ A)*TAU+ TIDEB(M)
                        TAU=TAU+DT
    2050                CONTINUE
   C               ENDDO
                   GO TO 4090
   C          ELSE
    3050           CONTINUE
                   N=1
   C               DOUNTIL NCASE.EQ.4.OR.NEND IS FINISHED
    3070                TIDE(N)=(B*TAU+ A)*TAU+ TIDEB(M)
                        TAU=TAU+DT
                        N=N+1
                        IF(TAU.GE.DTAU.AND.(N.LE.NEND)) NCASE=4
                        IF(.NOT.(TAU.GE.DTAU.OR.(N.GT.NEND)))GOTO3070
   C               ENDDO
    4090           CONTINUE
   C          ENDIF
              IF(.NOT.(NCASE.EQ.4)) GO TO 5010
                   TAU= TAU-DTAU
                   NBGN4=N
                   M=M+1
                   CALL NCASE4
     G                       (TIDEB, NBGN4 , NEND,SSTTS, DT
     G                       ,TT1, TT2, TT3, MCAP
     B                       , TIDE, M, TAU,NCASE)
    5010           CONTINUE
   C          ENDIF
              RETURN
              END
```

SYMBOLIC REFERENCE MAP (R=3)

```
      SUBROUTINE NCASE3     74/74   OPT=O TRACE                    FTN 4.6+433       01/21/83  16.18.59      PAGE     2

ENTRY POINTS     DEF LINE     REFERENCES
    4  NCASE3         1          49

VARIABLES      SN  TYPE             RELOCATION
  236  A           REAL                             REFS       22       31   DEFINED       18
  237  B           REAL                             REFS       22       31   DEFINED       19
    O  DT          REAL                  F.P.       REFS       23       32        43  DEFINED        1
  226  DTAU        REAL                             REFS       11       34        35       40  DEFINED      10
  227  DTAUT       REAL                             REFS       12       13        14  DEFINED       11
    O  M           INTEGER               F.P.       REFS       15       16        17       18       19       22       31
                                                      42       43  DEFINED         1       42
    O  MCAP        INTEGER               F.P.       REFS       20       43   DEFINED        1
  233  M1          INTEGER                          REFS       18       19   DEFINED       15
  234  M2          INTEGER                          REFS       18       19   DEFINED       16
  235  M3          INTEGER                          REFS     2*20  DEFINED        17
  240  N           INTEGER                          REFS       22       31        33       34       35       41
                                                 DEFINED       21       29        33
  241  NBGN4       INTEGER                          REFS       43  DEFINED        41
    O  NCASE       INTEGER               F.P.       REFS       39       43   DEFINED        1       34
    O  NEND        INTEGER               F.P.       REFS       21       34        35       43  DEFINED       1
    O  SSTTS       REAL                  F.P.       REFS       10       43   DEFINED        1
    O  TAU         REAL                  F.P.       REFS     2*22       23      2*31       32       34       35       40
                                                      43  DEFINED        1        23       32       40
    O  TIDE        REAL         ARRAY    F.P.       REFS        9       43   DEFINED        1       22       31
    O  TIDEB       REAL         ARRAY    F.P.       REFS        9     3*18      3*19       20       22       31       43
                                                 DEFINED        1
  230  TT1         REAL                             REFS       13       18        43  DEFINED       12
  231  TT2         REAL                             REFS       14       19        43  DEFINED       13
  232  TT3         REAL                             REFS       43  DEFINED        14

EXTERNALS          TYPE   ARGS        REFERENCES
       NCASE4               13            43

STATEMENT LABELS              DEF LINE   REFERENCES
    O  2050                       24         21
  113  3050                       28         20
  116  3070                       31         35
  147  4090                       37         26
  202  5010                       47         39

LOOPS  LABEL     INDEX      FROM-TO     LENGTH     PROPERTIES
   75  2050      N           21 24        14B          OPT

STATISTICS
  PROGRAM LENGTH                 265B      181
```

```
SUBROUTINE NCASE4      74/74   OPT=0 TRACE                    FTN 4.6+433        01/21/83  16.18.59        PAGE     1

                    SUBROUTINE NCASE4
          G                            (TIDEB,NBEGIN,  NEND,SSTTS,DT
          G                            . TT1, TT2, TT3 ,MCAP
          B                            , TIDE, M, TAU,NCASE )
      C             ..CASE4 IS CUBIC-PARABOLIC INTERPOLATION
      C             CALLED BY
      C                  NCASE3
      C             CALL TO
      C                  NCASE5
                    REAL TIDE(100) ,TIDEB(383)
                    DTAU=SSTTS
                    N=NBEGIN
      C             DOWHILE N.LE.NEND
                         GO TO 7010
       2050              M1=M+1
                         M2=M+2
                         MM1=M-1
                         A=TT1*(TIDEB(M1)- TIDEB(MM1))
                         B=TT2*(2.*TIDEB(MM1)- 5.*TIDEB(M)
            1              + 4.*TIDEB(M1)- TIDEB(M2))
                         C=TT3*(TIDEB(M2)- 3.*TIDEB(M1)+ 3.*TIDEB(M)
            1              - TIDEB(MM1))
                         TIDE(N)=((C*TAU+ B)*TAU+ A)*TAU+ TIDEB(M)
                         N=N+1
                         TAU= TAU+DT
                         IF(.NOT.(TAU.GE.DTAU )) GO TO 6070
                              TAU=TAU-DTAU
                              M=M+1
                              CONTINUE
       6070              ENDIF
      C
      C                  **CHECK FOR NCASE.EQ.5
                         M22=M+2
                         IF(.NOT.(MCAP.LT.M22.OR.(TIDEB(M22).EQ.O.)))GO TO 6075
                              NBGN5=N
                              NCASE=5
                              CALL NCASE5
          G                              (TIDEB, NBGN5, NEND
          G                              , TT1, TT2, DT
          Y                              , TIDE, M, TAU
                              N=NEND+1
       6075                   CONTINUE
      C                  ENDIF
       7010              IF(.NOT.(N .GT.NEND)) GO TO 2050
      C             ENDDO
                    RETURN
                    END
```

SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS	DEF LINE	REFERENCES
4 NCASE4	1	45

```
      SUBROUTINE NCASE4     74/74   OPT=O TRACE                   FTN 4.6+433        01/21/83  16.18.59       PAGE     2

VARIABLES      SN  TYPE            RELOCATION
   177  A          REAL                              REFS        23     DEFINED       18
   200  B          REAL                              REFS        23     DEFINED       19
   201  C          REAL                              REFS        23     DEFINED       21
     O  DT         REAL                 F.P.         REFS        25          36     DEFINED        1
   172  DTAU       REAL                              REFS        26          27     DEFINED       11
     O  M          INTEGER              F.P.         REFS        15          16          17       19        21        23        28
                                                       32        36     DEFINED        1       28
     O  MCAP       INTEGER              F.P.         REFS        33     DEFINED        1
   176  MM1        INTEGER                           REFS        18          19          21   DEFINED       17
   174  M1         INTEGER                           REFS        18          19          21   DEFINED       15
   175  M2         INTEGER                           REFS        19          21     DEFINED       16
   202  M22        INTEGER                           REFS      2*33     DEFINED          32
   173  N          INTEGER                           REFS        23          24          34       43   DEFINED        12        24
                                                       40
     O  NBEGIN     INTEGER              F.P.         REFS        12     DEFINED        1
   203  NBGN5      INTEGER                           REFS        36     DEFINED       34
     O  NCASE      INTEGER              F.P.      DEFINED         1          35
     O  NEND       INTEGER              F.P.         REFS        36          40          43   DEFINED        1
     O  SSTTS      REAL                 F.P.         REFS        11     DEFINED        1
     O  TAU        REAL                 F.P.         REFS      3*23          25          26       27        36
                                                  DEFINED         1          25          27
     O  TIDE       REAL       ARRAY     F.P.         REFS        10          36     DEFINED        1        23
     O  TIDEB      REAL       ARRAY     F.P.         REFS        10        2*18        4*19     4*21        23        33        36
                                                  DEFINED         1
     O  TT1        REAL                 F.P.         REFS        18          36     DEFINED        1
     O  TT2        REAL                 F.P.         REFS        19          36     DEFINED        1
     O  TT3        REAL                 F.P.         REFS        21     DEFINED        1

EXTERNALS          TYPE    ARGS        REFERENCES
       NCASE5                9              36

STATEMENT LABELS            DEF LINE    REFERENCES
    14  2050                   15          43
   111  6070                   29          26
   147  6075                   41          33
   150  7010                   43          14

STATISTICS
  PROGRAM LENGTH              204B        132
```

```
SUBROUTINE NCASE5      74/74    OPT=0 TRACE                FTN 4.6+433        01/21/83  16.18.59        PAGE      1

 1                    SUBROUTINE NCASE5
               G                     (TIDEB,NBEGIN,  NEND
               G                     , TT1 ,TT2, DT
               B                     , TIDE, M, TAU        )
 5        C           ..CASE5 IS PARABOLIC END POINT INTERPOLATION
          C           CALLED BY
                      REAL TIDE(100) ,TIDEB(383)
                      A=TT1*(TIDEB(M)-TIDEB(M-1))
                      B=TT2*(TIDEB(M+1)-2.*TIDEB(M)+TIDEB(M-1))
10                    DO 3010 N=NBEGIN,NEND
                         TIDE(N)=(B*TAU+ A)*TAU+ TIDEB(M)
                         TAU=TAU+DT
           3010          CONTINUE
          C           ENDDO
15                    RETURN
                      END


     SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE      REFERENCES
   4  NCASE5         1            15

VARIABLES      SN  TYPE           RELOCATION
  52  A            REAL                            REFS        11   DEFINED       8
  53  B            REAL                            REFS        11   DEFINED       9
   0  DT           REAL                 F.P.       REFS        12   DEFINED       1
   0  M            INTEGER              F.P.       REFS       2*8       3*9      11   DEFINED        1
  54  N            INTEGER                         REFS        11   DEFINED      10
   0  NBEGIN       INTEGER              F.P.       REFS        10   DEFINED       1
   0  NEND         INTEGER              F.P.       REFS        10   DEFINED       1
   0  TAU          REAL                 F.P.       REFS      2*11        12   DEFINED       1        12
   0  TIDE         REAL        ARRAY    F.P.       REFS         7   DEFINED       1        11
   0  TIDEB        REAL        ARRAY    F.P.       REFS         7       2*8      3*9       11   DEFINED       1
   0  TT1          REAL                 F.P.       REFS         8   DEFINED       1
   0  TT2          REAL                 F.P.       REFS         9   DEFINED       1

STATEMENT LABELS                  DEF LINE    REFERENCES
   0  3010                           13           10

LOOPS  LABEL     INDEX      FROM-TO     LENGTH     PROPERTIES
  33   3010      N           10 13        14B          OPT

STATISTICS
  PROGRAM LENGTH                  100B        64
```

```
SUBROUTINE SR        74/74    OPT=O TRACE                 FTN 4.6+433        01/21/83  16.18.59        PAGE     1

   1                   SUBROUTINE SR
                  G                 ( ISR, JCAP, MCAP
                  B                 , TIDEB, X1 )
              C        CALLED BY
   5          C             INTRP1
                       DIMENSION TIDEB(383), X1(384)

              C        ..STORE TIDAL HEIGHTS(TIDEB, WITH SST SPACING)
              C        IN X1 ARRAY IN THEIR CORRESPONDING POSITIONS
  10                   IF(.NOT.( ISR.EQ.1)) GO TO 4010
                            JJ= JCAP-1
                            DO 3070 II=1,MCAP
                                 JJII=JJ+II
                                 IF(JJII.GT.383)STOP"IN SR,NEAR LABEL3070"
  15                             X1(JJII)= TIDEB(II)
               3070              CONTINUE
              C             ENDDO
              C             **ZERO OUT( EXCESS AREA IN TIDEB)
               4010         CONTINUE
  20          C        ENDIF

              C        ..RESTORE TIDAL HEIGHTS(TIDEB, WITH SST SPACING)
              C        FROM X1 ARRAY
                       IF(.NOT.( ISR.EQ.2)) GO TO 6070
  25                        CALL MOVE( 0.0,TIDEB(1), 383)
                            IJ=JCAP-1
              C             **RESTORE TIDE VALUES FROM X1
                            DO 6063 II=1,MCAP
                                 I=IJ+II
  30                             IF(I.GT.383) STOP "STOPPED IN SR"
                                 TIDEB(II)= X1(I)
               6063              CONTINUE
              C             ENDDO
               6070         CONTINUE
  35          C        ENDIF
                       RETURN
                       END


     SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
   4  SR                 1         36

VARIABLES       SN  TYPE           RELOCATION
  112  I            INTEGER                          REFS       30        31   DEFINED       29
  107  II           INTEGER                          REFS       13        15        29        31   DEFINED       12       28
  111  IJ           INTEGER                          REFS       29   DEFINED        26
    0  ISR          INTEGER                F.P.      REFS       10        24   DEFINED        1
    0  JCAP         INTEGER                F.P.      REFS       11        26   DEFINED        1
  106  JJ           INTEGER                          REFS       13   DEFINED        11
  110  JJII         INTEGER                          REFS       14        15   DEFINED       13
    0  MCAP         INTEGER                F.P.      REFS       12        28   DEFINED        1
    0  TIDEB        REAL         ARRAY     F.P.      REFS        6        15        25   DEFINED        1       31
```

```
      SUBROUTINE SR          74/74   OPT=O TRACE                          FTN 4.6+433        01/21/83  16.18.59        PAGE     2

VARIABLES     SN  TYPE            RELOCATION
    O  X1         REAL        ARRAY     F.P.          REFS          6        31    DEFINED        1        15

EXTERNALS             TYPE     ARGS          REFERENCES
       MOVE                      3                25

STATEMENT LABELS                DEF LINE    REFERENCES
    O  3070                        16           12
   44  4010                        19           10
    O  6063                        32           28
   76  6070                        34           24

LOOPS   LABEL      INDEX      FROM-TO      LENGTH     PROPERTIES
   26   3070     * II          12  16        15B                   EXT REFS
   60   6063     * II          28  32        15B                   EXT REFS

STATISTICS
  PROGRAM LENGTH                  136B         94
```

```
                  SUBROUTINE SSTGTD
              G                    ( K, IUNIT, IMODE, KOLD
              Y                    , X1, X2, D1, D2        )
          C       CALLED BY
          C            INTRP1
                  DIMENSION X1(384), X2(384), D1(384), D2(384)
          C       **
          C       **COMPUTE
                  I1= IUNIT+ 2*(IMODE-1)

                  I2= I1+1
                  IF(.NOT.((KOLD.GE.K).OR.(K.FQ.1).OR.(KOLD.EQ.-999))) GO TO 2010
                       REWIND I1
                       REWIND I2
            2010       CONTINUE
          C       ENDIF
                  INCK= K-KOLD
                  IF(.NOT.( INCK.LE.O.OR.KOLD.EQ.-999)) GO TO 2015
                       INCK=K+1
            2015       CONTINUE
          C       ENDIF

          C       ..POSITION THE SSTGTD FILES SO THAT THE DATA
          C       W.R.T. THE SST NUMBER K WILL GO INTO X1 AND D1 ARRAYS
                  INCK1= INCK-1
                  IF(.NOT.( INCK1.NE.O)) GO TO 4050
                       DO 4030 I=1,INCK1
                            CALL INOUT(I1, O, X1,D1, 384)
            4030            CONTINUE
          C            ENDDO
                       GO TO 4080
          C       ELSE
            4050       DO 4060 J=1,384
                            X1(J)=X2(J)
                            D1(J)=D2(J)
            4060            CONTINUE
          C            ENDDO
            4080       CONTINUE
          C       ENDIF

                  IF(.NOT.( K+1.EQ.361)) GO TO 4090
                       REWIND I1
                       REWIND I2
            4090       CONTINUE
          C       ENDIF

          C       ..PUT SSTGTD VALUES W.R.T. SST NUMBER(K+1)
          C       INTO X2 AND D2 ARRAYS
                  CALL INOUT( I1, O, X2, D2, 384)
                  RK=X1(384)
                  IK=D1(384)
                  RETURN
                  END
```

```
     SUBROUTINE SSTGTD     74/74   OPT=0 TRACE                     FTN 4.6+433       01/21/83  16.18.59       PAGE     2

     SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE     REFERENCES
    4  SSTGTD           1          52

VARIABLES     SN  TYPE          RELOCATION
     0  D1         REAL      ARRAY     F.P.        REFS        6        28       51    DEFINED        1        35
     0  D2         REAL      ARRAY     F.P.        REFS        6        35       49    DEFINED        1
   164  I        * INTEGER                       DEFINED      27
   167  IK       * INTEGER                       DEFINED      51
     0  IMODE      INTEGER             F.P.        REFS        9   DEFINED        1
   162  INCK       INTEGER                         REFS       18        25  DEFINED       17        19
   163  INCK1      INTEGER                         REFS       26        27  DEFINED       25
     0  IUNIT      INTEGER             F.P.        REFS        9   DEFINED        1
   160  I1         INTEGER                         REFS       11        28       49    DEFINED        9
                                                 I/O REFS     13        42
   161  I2         INTEGER                       DEFINED      11  I/O REFS       14       43
   165  J          INTEGER                         REFS     2*34      2*35  DEFINED       33
     0  K          INTEGER             F.P.        REFS     2*12        17       19       41    DEFINED       1
     0  KOLD       INTEGER             F.P.        REFS     2*12        17       18    DEFINED        1
   166  RK       * REAL                          DEFINED      50
     0  X1         REAL      ARRAY     F.P.        REFS        6        28       50    DEFINED        1        34
     0  X2         REAL      ARRAY     F.P.        REFS        6        34       49    DEFINED        1
        VARIABLES USED AS FILE NAMES. SEE ABOVE

EXTERNALS          TYPE   ARGS        REFERENCES
        INOUT                5              28         49

STATEMENT LABELS                DEF LINE   REFERENCES
    40  2010                        15         12
    54  2015                        20         18
     0  4030                        29         27
    75  4050                        33         26
     0  4060                        36         33
   110  4080                        38         31
   121  4090                        44         41

LOOPS  LABEL     INDEX      FROM-TO     LENGTH    PROPERTIES
    64  4030    * I           27 29        7B               EXT REFS
    76  4060      J           33 36       11B          OPT

STATISTICS
  PROGRAM LENGTH                212B       138
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