Pioneer Venus Orbiter OETP Data - 7/23/93

INTRODUCTION

This document describes the various Orbiter Electron Temperature Probe (OETP) data products that have been submitted to the National Space Science Data Center and the Planetary Data System.

The OETP has been described by Krehbiel et al. (1980). The instrument uses two cylindrical Langmuir probes (axial and radial) which protrude into the surrounding plasma to measure the ionospheric electron density and temperature (Ne and Te), the ion density (Ni), and the spacecraft potential, (Vs). The probes were operated independently by a common electronics unit. All of the data submitted here were derived from the radial probe, since its longer boom provided measurements over a wider range of Ne, a fact that caused the investigators to dedicate the limited telemetry allocation to that probe during most of the PVO mission. During the first 70 orbits, the axial probe was used more often, so many of these early orbits are not represented in the archived OETP data.

As an ionosphere instrument, the OETP is capable of accurate plasma measurements only while the spacecraft was within the ionosphere; an interval of only a few minutes during each 24 hour orbit. However, the Ne measurements made at higher altitudes have proved useful, so they are included in the High Resolution file which extend above the ionosphere. These data are useful for the study of smaller scale features and for identifying the location of the ionopause, the bow shock. The measurements of photoelectron emission from the probe (net ion current in regions of very low Ne) have permitted the intensity of the solar EUV flux to be derived, and a file of daily values of this current is presented. Details of the plasma measurements method can be found in the Krehbiel et al. (1980) paper, and the method for solar EUV flux measurement is described by Brace et al.(1988). The data formats for these files are described at the end of this report. For further information on access to the OETP raw telemetry data please contact Robert Theis or Walter Hoegy, Code 914, NASA/Goddard Space Flight Center, Greenbelt, MD 20771. (301-286-3620, and 301-286-3837).

The OETP measurements have been used in many Venus investigations. Among these is a paper by Theis et al. (1984) who modelled the Ne and Te data to describe the local time and altitude variations in the Venus ionosphere and their implications for nightward ion flow. Brace et al. (1987, 1990) used the OETP data to examine the nightside ionosphere out to very high altitudes. A more complete bibliography publications by the OETP investigators is given at the end of this document.

TYPES OF OETP DATA Products

Five types of OETP data files are available in the NSSDC and PDS. These are described briefly in this section. More details on the measurements and their accuracies are provided in later sections.

(1) The UADS. The Unified Abstract Data System, UADS, was conceived as a file combine the data from all of the PVO in situ instruments on a common time base to facilitate analysis. The temporal resolution of 12 seconds was adopted since it was approximately equal to the spin period of the satellite which in most instruments determined the spatial resolution of the measurements. data. The OETP input to the UADS includes measurements of Ne, Te, and Vs, based on computer fitting of individual voltampere curves. Since the curves were recovered at rates either higher of lower than the UADS rate of 12 seconds, the value of the parameter at the UADS entries had to be obtained by interpolation of nearby measurements. When the spacecraft data rate was very low not all UADS 12 second time slots were filled to avoid interpolation over too large an interval.

UADS measurements are only provided when the spacecraft is in the ionosphere and the density exceeds a threshold that depends on various experimental background factors, such as spacecraft photoemission, spacecraft charging, and electrical shielding of the probe by the spacecraft ion sheath. For this reason, the UADs is not the best source of information on the ionopause and its density gradients. These feasures are better resolved in the High Resolution Ne file that is described next.

(2) The High Resolution Ne File. These data are based on measurements of the electron saturation current or the ion saturation current taken from as many voltampere curves as the telemetry data rate permitted. Since Ne is assumed equal to Ni everywhere in the ionosphere, either can be used as a measure of Ne. The ion current is used at high densities (Ni>4x104cm-3) and the electron current is used at lower densities. Typically, 4 to 8 high resolution density samples are obtained in the interval between recovered voltampere curves, although this ratio is bit rate dependent. This provides Ne and Ni measurements at much smaller intervals than is possible from the voltampere curves themselves. High resolution measurements are typically available at 2 to 8 second intervals depending upon the telemetry rate available to the OETP at the time.

The measurements in the High Resolution Ne file are given for a one hour period centered on periapsis, in spite of the fact that the spacecraft may be outside the ionosphere for much of this interval. The measurements made outside the ionosphere are heavily spin modulated by spacecraft photoelectrons, but they are included because they show the ionopause density gradient and other real Ne structure that lies above the ionosphere (such as; bow shocks, plasma clouds, magnetosheath electron fluxes, spacecraft photoelectron densities, etc). These features are not generally found in the UADS file which only contains measurements made within the ionosphere. More information on the High Resolution Ne measurements, and their limitations is contained in the section on measurement accuracy.

(3) The Ionopause File. This file gives the orbit-by-orbit times and locations of the ionopause crossings, which are evident as sharp gradients in Ne at the top of the ionosphere. (These crossings always occur within 30 minutes of periapsis, so they may be seen in the High Resolution Ne files).

(4) The Bow Shock File. This file gives the orbit-by-orbit times and locations of the bow shock crossings, which are characterized by distinct changes in Ne. Multiple shock crossing are listed if they are sufficiently separated to be resolved accurately. (Bow shock crossings will be evident in the High Resolution Ne File when they occurred within 30 minutes of

periapsis).

(5) The Solar EUV Daily Values File. This file gives the magnitude of the photoemission current from the radial probe, Ipe, (in units of 10^-9 amps). Ipe dominates the ion current measurements outside the Venusian ionosphere, making possible the serendipitous measurement of the total solar EUV flux. The latter is an important parameter because solar EUV is the main source of ionization and heating for the Venusian thermosphere and ionosphere. The method is discussed by Brace et al., (1988).

The pe current measurements are taken just before PVO leaves the solar wind and enters the magnetosheath (usually an hour or two before periapsis). This approach provides the solar EUV flux that the Venus thermosphere received just before the periapsis measurements. The maximum value of the spin modulated Ipe is taken because it corresponds to a probe orientation perpendicular to the Sun when the maximum area of the probe is exposed to the Sun. Ipe is proportional to the intensity of the ionizing component of solar radiation, so it is possible to derive the total solar EUV (and far UV) flux. Ly alpha contributes approximately half of the Ipe while nearly all of the rest is produced by radiation between 200 A and 1200 A which ionizes, excites and dissociates thermospheric neutrals. The equation for conversion to solar EUV total flux is described later.

Raw Data Tapes

The OETP raw telemetry data were provided by the PV Project on tapes called Experiment Data Records (EDRs); one tape for each of the approximately 5000 orbits. To conserve storage space, the EDRs were compacted onto 6250 bpi magnetic tapes, each containing the data from 40 to 50 consecutive orbits. These compacted EDRs are now stored at Goddard Space Flight Center, and the original EDRs were returned to NASA for reuse. There is no current plan for submission of the 100 or so compacted tapes to the NSSDC or the PDS for longer term storage, but they are available if such a plan arises. There is a tentative plan to further condense the raw OETP data onto optical disks for ease of storage and permanence. (For further information on the current status of the raw data, contact Walter R. Hoegy or Robert F. Theis, Code 910, NASA/GSFC, Greenbelt, MD 20771, phone 301-286-3837 or 286-3620).

Voltampere Curves

Note that raw voltampere curves are not included in the NSSDC and PDS data submissions; only the analyzed products of curve fitting. The curves themselves can only be obtained by accessing the OETP compacted magnetic tapes and applying appropriate computer codes that strip out the curves from the OETP bit stream. These data products are not usually archived by the data centers. This is unfortunate because we have found the curves to be rather useful in unanticipated ways. For example, small scale Ne structure has been discovered as wavelike modulation of the voltampere curves (see reference 80 at end of report). Also, non-maxwellian electron energy distributions are sometimes seen as nonexponential electron retarding regions. (See Walter Hoegy or Robert Theis at NASA/GSFC for information on the OETP raw data base and the necessary programs to access the curves).

MORE DETAILED DESCRIPTION OF THE OETP DATA FILES

The UADS File

This file gives the Ne, Te and Vs measurements derived by fitting the radial probe voltampere curves taken whenever PVO was within the ionosphere (ie., between the inbound and outbound ionopause crossings). Data from essentially every orbit in 1979 and 1980 included ionosphere transits. After the summer of 1980, however, periapsis could no longer be maintained at low altitudes, and it rose slowly. After April 1981 periapsis was above the altitude of the dayside ionopause, so the spacecraft encountered the ionosphere only in the terminator regions and on the nightside where the ionosphere extends to much higher altitudes. Dayside measurements again became available early in 1992 when periapsis returned to low enough altitudes. The PVO Entry period of between July and October 1992 provided only nightside periapsis data. During the intervening period (1981-91), only nightside UADS measurements in the high altitude (downstream) ionosphere were available. Note that High Resolution Ne data from the 1981-91 interval provide measurements in the dayside magnetosheath and in the solar wind, but these data have limited accuracy because of spacecraft photoelectron contributions. See Brace et al, 1988 (ref. 53) in the bibliography for further details on the interpretation of High Resolution measurements made outside the ionosphere.

As noted earlier, the geophysical values are listed at 12 second intervals in the UADS. Each OETP entry represents a time-weighted average of those radial probe measurements taken within approximately 10 seconds of the UADS-assigned times. If no voltampere curves were recovered within that 20 second interval (this occurs at very low spacecraft telemetry rates), no UADS value is entered in that 12 second slot. The instrument actually takes voltampere curves at a rate of 120/minute, but telemetry rate limitations permit the recovery of raw voltampere curves at intervals between 4 to 32 seconds, depending upon the telemetry rate and spacecraft data format currently in use.

The Ne values in the UADS file may actually be based on either the ion or electron current collected by the probe, depending upon the magnitude of the density at the time. The radial probe electron currents saturate the electrometer when Ne > 4x10^4 cm^-3, so it is necessary to switch over to Ni measurements at that point. Since the ion currents are about a factor of 50 smaller, the Ni measurements can be made up to densities of about 2 x 10^6 cm^-3, much greater than is present anywhere in the Venus ionosphere. We assume that Ni = Ne everywhere in the ionosphere, so either may be used to construct the UADS file. To minimize any discontinuity that may occur at the Ne/Ni switch-over point due to systematic measurement errors, Ne is normalized to Ni using a small universal correction factor. This factor is 0.7, and is based on comparisons of the overlapping Ne and Ni measurements from many individual orbits.

There are good theoretical reasons to believe that the Ni measurements are inherently more accurate at densities exceeding 3 or 4x10^4 cm^-3, so this normalization approach improves the accuracy of the Ne measurements. The Ni measurements become less accurate at lower densities because of uncertain changes in the ion composition, ion drift velocity, and a positive ion current component produced by photoelectrons (Ipe) leaving the probe. Ipe becomes comparable to the true ion currents at Ni of approximately 1x10^4 cm^-3. The pe currents produce a spin modulated signal that is modelled using measurements made in the solar wind just prior to the bow shock crossing where the ambient densities are too small to produce detectable ion currents. This spin modulated Ipe waveform, whose amplitude is different from orbit to orbit because of solar EUV variations, is subtracted from the net positive current measurements made in the subsequent ionospheric passage. This subtraction gives the true ion current which is directly convertible to Ni. The spin maximum Ipe for each orbit is also used to construct the solar EUV file, as is described later.

Because of the low spatial resolution of the UADS, and the fact that only ionosphere data are included, this file is not the best source of information about the ionopause. Features such as the ionopause, and plasma clouds above the ionopause, are resolved better using the High Resolution Data File which is not restricted to measurements within the ionosphere. This file is discussed next.

High Resolution Ne File

The High Resolution file provides measurements of Ne (or Ni) within 30 minutes either side of periapsis at somewhat higher resolution than is possible from the voltampere curves. However, these measurements are less accurate when the spacecraft is outside the ionosphere, where Ne is typically well below 100 cm^-3. In sunlight, spacecraft photoelectron densities at the radial probe location are of the order of 30-50 cm^-3. In darkness, the Ne measurements can be made down to densities of about 2 cm^-3 because the pe background is absent. However, the measurements made in the Venus umbra are often degraded at low densities because of the presence of hot electrons that charge the spacecraft to potentials that lie beyond the range of the OETP sweep voltage. This makes it impossible to drive the probe positive with respect to the plasma potential. In addition, deBye shielding causes the probe to become enveloped in the ion sheath of the spacecraft at very low densities, further reducing its access to the ambient ionospheric plasma. Empirically derived corrections for this effect have been applied to the high resolution data in order to provide at least a lower limit of Ne, but the errors could exceed a factor of 2 at densities below 10 cm^-3. This correction does not allow Ne to be less than 2 cm^-3. When the electron current at maximum positive voltage is less than a certain very low value an Ne value of 2 cm^-3 is entered in the High Resolution file simply to serve as an upper limit on Ne, and to show that data were actually being taken.

In summary, the high resolution Ne measurements provide about a factor of 8 higher resolution than the UADS file whose resolution is limited by the recovery rate of raw voltampere curves. Therefore the high resolution data better resolve such small scale features as the ionopause and the plasma clouds often found above the ionopause. Also, the UADS densities often stop somewhere within the ionopause density gradient, so this feature can best be resolved using the High Resolution data. However, certain artifacts have not been removed from the data, so one must be careful not of over-interpret them. (See section on accuracy

Ionopause and Bow Shock Crossings

The ionopause and bow shock crossing times and locations are easily identified in the high resolution Ne measurements (Theis et al., 1980). These files contain the UT, altitude, latitude, SZA and local time of each crossing.

On the dayside, the ionopause is taken (somewhat arbitrarily) at the level in the steep gradient of the ionopause where Ne = 1x10^2 cm^-3. On the nightside, the ionopause is selected at somewhat lower densities because the absence of spacecraft photoelectrons lowers the Ne measurement threshold. In both cases, the intent is to identify the ionopause as the point where the first rise of Ne above the background density occurs. Of course, the ionopause itself is not a point but is the extend region in which the ionopause density gradient occurs.

The bow shock is a much more discrete feature in the data than the ionopause. Multiple shock crossings sometimes occur because the shock often moves at higher velocities than the satellite. In these cases, only the outer most shock crossing is recorded, unless the separation between the crossings is greater than a minute or two. The occurrence of multiple shocks in the Bow Shock File provides a record of the orbits in which the solar wind itself was probably highly variable. Because of the geometry of the orbit, most shock crossings were in the range of 45 to 135o SZA. However, the nose region of the shock was explored between 1985 and 1987 when PVO periapsis was near the equator and was at altitudes between 2000 and 2300 km. During these years near solar minimum the nose of the shock often moved down into that altitude range (Russell et al, 1988). During the subsolar passages of these years, the orbit approximately paralleled the shock, sometimes inside, sometimes outside, thus providing interesting snapshots of its movements.

Solar EUV Daily Values

This file contains the daily average value of the photoelectron emission current, Ipe, from the radial probe, usually measured about 1 hr before periapsis. The Ipe values are given in units of 10^-9 amperes. The data cover the interval from 1979 through early 1992 when periapsis got low enough to cause photoelectric yield changes that have not been fully resolved and corrected for appropriately. The data provided cover orbits 1 to 4800. After orbit 4800, when PVO began to enter the atmosphere, the Langmuir probe could no longer be kept clean, and as a result the yield changed For further details, contact Walt Hoegy at GSFC code 914, (301) 286-3837 or email hoegy@mite.gsfc.nasa.gov.

The daily Ipe measurements can be converted into the total solar EUV flux (VEUV) using the following the equation given by Brace et al., (1988),

VEUV = 1.53 x 1011 Ipe   (photons/cm2/s)

VEUV represents the total solar flux, weighted by the known wavelength-dependent yield of the collector. A standard Hinteregger solar EUV/UV spectrum is assumed to derive the coefficient, but the measurement is relatively insensitive to this assumption over the typical range of variations in the solar spectrum.

The VEUV data have been useful in the study of solar EUV effects on the ion production and electron heating rates in the Venus ionosphere. VEUV variations have been correlated with changes in the density and temperature of the ionosphere (Elphic et al., 1984), the height of the bow shock (Alexander et al., 1985, Russell et al., 1988), and changes in the density and temperature of the thermosphere (Mahajan et al., 1990).

DATA QUALITY/ACCURACY

UADS Accuracy

The UADS data are based on operator-assisted voltampere curve fits. The absolute accuracy of the data depends primarily upon the accuracy of the Langmuir probe theory (Krehbiel, et al., 1980) and our success in avoiding the inclusion of data from curves that were obtained in situations in which the theory does not apply (e.g., probe in wake of the telemetry antenna, very low densities, pe contamination, spacecraft potential too negative, etc.). Where these effects have been avoided, the errors in Te should not exceed 5% when Ne exceeds 500 cm^-3 in sunlight and about 30 cm^-3 in darkness. However, Te errors may be larger in regions of great spatial structure where the plasma parameters change while they are being measured, or in regions where the electron energy distribution is nonmaxwellian or appears to have two temperatures. These conditions are often found in the nightside ionosphere and at the ionopause. In these cases, the curve-fitting is done so as to measure the temperature of the lower temperature component of the plasma. The curves would have to be refitted to obtain information on the higher temperature component.

The accuracy of the Ne measurements is determined by the accuracy of the Ni measurements to which they are normalized by a fixed factor that was determined by comparisons at densities in the vicinity of 4 x 10^4 cm^-3. Therefore the Ne accuracy is nominally 10%, but the error increases at low densities where pe background and/or spacecraft charging effects can be important, as described earlier. Ne is given in the UADS file for densities down to 2 cm^-3 and Te for densities down to 10 cm^-3, which are observed only in the nightside ionosphere and ionotail. The Ne error is expected to grow as the density approaches these limits, but the Te measurements are less subject to error at low densities because knowledge of Vs is not needed to obtain the temperature. In spite of the reduced accuracy, Ne measurements below 30 cm^-3 are retained in the UADS file because they do reflect real variations that may be of interest even when their absolute accuracy may be uncertain by a factor of 2 or more. Examples include the detection of weak ionospheric tail rays and plasma clouds (Brace et al., 1987).

The error in Ni is not expected to exceed 10% at densities above 4 x104 cm^-3. Ne is used for densities below 4 x10^4 cm^-3. As noted earlier, Ne is normalized to Ni at their overlap point to gain the greater inherent accuracy of the ion measurements. The normalization factor is based on the overlapping Ne and Ni measurements from many orbits, and the factor does not change throughout the mission. Therefore, small discontinuities in the density measurement may sometimes be seen at the crossover point if ionospheric conditions lead to unusual spacecraft potentials, ion compositions, or other factors that are assumed constant when adopting a fixed relationship between the ion and electron currents. We assume that the normalization factor remains constant over the full range of Ne, and this may not be correct.

High Resolution File Accuracy

In general, the high resolution Ne measurements have a lower absolute accuracy than the UADS (voltampere curve) measurements because factors such as the spacecraft potential and Te are not available to calculate Ne more precisely. To reduce such errors in the high resolution data, they are normalized to the voltampere curve measurements. This normalization is entirely different from the Ne-Ni normalization employed in deriving the UADS data.

Another source of error in the High Resolution Ne measurements is the jump discontinuities that occur when the spacecraft passes from sunlight to shadow. An abrupt change in spacecraft potential occurs at that point, and this changes the probe voltage which is referenced to the spacecraft. The Ne measurements cannot easily be corrected for this change because they are not based on voltampere curves but measurements at a fixed positive potential. Therefore a discontinuity may occur in Ne at the sunlight-shadow boundary if Ne is sufficiently low that spacecraft photoelectron emission affects the spacecraft potential.

The precision of the high resolution data is probably somewhat better than that of the UADS data because the latter may suffer from the effects of volt ampere curve distortion due to small scale density variations and spin effects which do not show up in the single point samples used in the high resolution measurements. This feature makes the high resolution data more valuable in resolving small scale, and small amplitude plasma structure.

Ionopause Location Accuracy

The ionopause location is selected at that point in the steep gradient of the ionopause where Ne crosses through the level of 1x10^2 cm^-3. When the spacecraft is in darkness, the pe background is absent and the ionospheric Ne is also much lower, so the ionopause is identified as the first rise in Ne above whatever background is present. The ionopause is identified by a human operator who views each high resolution Ne pass plot on an interactive computer terminal. He selects the ionopause somewhat subjectively as the time of the first rise above the background Ne, which may consist of magnetosheath plasma or photoelectrons. The 40 minute pass plots used for this purpose provide only a 5-10 second accuracy in the crossing times. When irregularities or waviness in the ionopause produce several ionopause crossings, the outer most crossing is the only one identified.

Bow Shock Location Accuracy

The bow shock is selected from 200 minute pass plots by marking the UT of the sharp change in the amplitude of Ne at the shock discontinuity. The resolution of the shock crossing time is of the order of 1 minute on these plots, but this could be improved to a few seconds if expanded plots were used. There is no plan currently to provide the ultimate resolution available in bow shock crossing time and location.

The solar EUV measurement accuracy

The Ipe measurements themselves are made with an absolute accuracy of 1 to 2%, depending upon where the current falls within the decade range of the ranging electrometer. The absolute accuracy of the measurements is also limited by our knowledge of the photoelectric yield of the radial probe collector, and our assumption that a Hinteregger standard EUV/UV spectrum is correct. We estimate a 10% absolute accuracy in the total EUV flux and a 1 to 2% relative accuracy or precision provided by the accuracy of the current measurements themselves. See Brace et al.(1988) for details of the method.

FORMAT OF THE FILES

The following is a guide to reading the data in the Pioneer Venus Unified Abstract Data System tape format. The first record gives the number of parameters, followed by the 4 letter mnemonic that identifies the parameter. The parameters given are ELTE (Te in units of Deg. K), ELNE, (Ne in number/cc), and VS (Vs in volts) in following format

```
3 ELTE ELNE VS
```

The second record contains the format which may be used to read all of the remaining records.

```
(I8,I9,I5,I6,3F11.2)
```

The third record contains values which are used to indicate that no measurement was available.

```
       0        0    0     0 9999999.00 9999999.00 9999999.00
```

The fourth record to the end of the file, consists of the date (year and day of year), the UT (milliseconds), the orbit number and the time from periapsis (in seconds). The last three columns are Te, Ne, and Vs.

```
 1978339 54454817    1  -228 9999999.00     574.00      -2.10
 1978339 54550817    1  -132    5470.00   12900.00      -0.42
 1978339 54682817    1    12    3960.00   11800.00      -0.57
 1978339 54814817    1   144    6900.00    1090.00       0.38
 1978340 51262817    2  -444 9999999.00     243.00       2.84
 1978340 51322817    2  -384    8760.00   55800.00      -1.75
```

The next file contains ionopause crossing information. This file is formatted for printing and is self explanatory.

```
ORBIT  DATE PERIAPSIS                    INBOUND CROSSING                       OUTBOUND CROSSING
             HH:MM:SS    SECS  HH:MM:SS    LAT  LST    ALT    SZA   SECS  HH:MM:SS    LAT  LST   ALT   SZA
   1  78339  15:11:12   54409  15: 6:49   39.7 15.6   601.   63.4  54884  15:14:44    1.5 16.4   522.  66.2
   2  78340  14:21:42   51276  14:14:36   52.1 15.2   832.   66.4  52130  14:28:50  -15.8 16.8   834.  72.9
   3  78341  14:31:46   51971  14:26:11   45.9 15.6   579.   66.2  52690  14:38:10  -13.0 16.9   687.  73.7
   4  78342  14:40:12   52272  14:31:12   59.6 14.9  1110.   69.5  53271  14:47:51  -18.7 17.1   867.  77.1
```

The next file contains bowshock crossing information. This file is formatted for printing and is self explanatory.

```
ORBIT  DATE PERIAPSIS                    INBOUND CROSSING                       OUTBOUND CROSSING
             HH:MM:SS    SECS  HH:MM:SS    LAT  LST    ALT    SZA   SECS  HH:MM:SS    LAT  LST    ALT   SZA
   1  78339  15:11:12   51512  14:18:32   43.9  5.4 12044.  100.2      0   0: 0: 0    0.0  0.0      0.   0.0
   2  78340  14:21:42   49079  13:37:59   49.1  5.8  9899.   96.4      0   0: 0: 0    0.0  0.0      0.   0.0
   3  78341  14:31:46   50202  13:56:42   56.3  6.3  7725.   91.3      0   0: 0: 0    0.0  0.0      0.   0.0
   4  78342  14:40:12   49872  13:51:12   45.1  5.8 11284.   96.2  57078  15:51:18  -67.8  2.0 16416. 109.1
```

The next file contains Venus Solar Flux information in the form of Ipe values in units of 10^-9 amperes.. This file is formatted for printing and is self explanatory. The total solar EUV flux (VEUV)is derived by multiplying by the factor given in the equation presented earlier.

```
Dates 78339-78348  Orbits     1-  10 ipe   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
Dates 78349-78358  Orbits    11-  20 ipe   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
Dates 78359-79003  Orbits    21-  30 ipe   0.00  0.00  0.00  0.00 10.30  0.00  0.00  0.00  0.00 10.30
Dates 79004-79013  Orbits    31-  40 ipe   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
Dates 79014-79023  Orbits    41-  50 ipe   0.00 10.30  0.00  0.00  0.00 10.30 10.02 10.02  0.00 10.02
Dates 79024-79033  Orbits    51-  60 ipe   0.00  0.00 10.02 10.11  0.00  0.00  0.00  0.00  0.00  0.00
Dates 79034-79043  Orbits    61-  70 ipe   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00 10.98 11.19
Dates 79044-79053  Orbits    71-  80 ipe  11.03 11.19 10.34  9.74 10.39 11.40 11.61  0.00 11.40 10.78
Dates 79054-79063  Orbits    81-  90 ipe   9.52  0.00  9.70 10.11  9.97  0.00  9.97  9.65  0.00  9.52
Dates 79064-79073  Orbits    91- 100 ipe   9.70 10.39 10.54 10.59 10.78 10.83 10.98 10.88 10.83  0.00
```

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