DATA PRODUCT SPECIFICATION FOR WAVE STATISTICS

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Document Control Sheet

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0-02	2012-07-05	Merged MOTPLAT, WAVEDIR, and WAVESPC into this one document.	Matthias Lankhorst
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1-01	2012-10-10	Add description of data products from waves-measuring ADCPs	Jonathan Fram; ECR 1300-00297

Signature Page

This document has been reviewed and approved for release to Configuration Management.

OOI Senior Systems Engineer: ______________________________

Date: 2012-09-05

This document has been reviewed and meets the needs of the OOI Cyberinfrastructure for the purpose of coding and implementation.

OOI CI Signing Authority: ______________________________

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Table of Contents

1 Abstract

This document describes the OOI data products “WAVSTAT”, i.e., the data products obtained from the “WAVSS” class of instruments. The data products describe the surface wave field of the ocean, as well as the motion of the platforms carrying the instruments. The instruments are made by AXYS Technologies, Inc.; the instrument model is: TRIAXYS™ OEM (Original Equipment Manufacturer) Directional Wave Sensor.

Because the WAVSS instruments perform the necessary calculations internally, this document does not describe any computations. Instead, it points to the relevant sections in the instrument manual and calls out where to capture the data in the data streams that the instruments report.

A known limitation of how these instruments are used in the OOI stems from their mounting on large buoys. The frequency response of how the buoys move in the wave field is not well known, and this will degrade data quality for some of the data products described in this document.

Wave statistics will be measured by an acoustic Doppler current profiler (ADCP) mounted on the seafloor at the two shallowest OOI mooring locations. This document also describes how wave statistics are computed from raw ADCP data.

2 Introduction

2.1 Author Contact Information

Please contact Matthias Lankhorst (mlankhorst@ucsd.edu) or the Data Product Specification lead (DPS@lists.oceanobservatories.org) for more information concerning the algorithm and other items in this document.

2.2 Metadata Information

2.2.1 Data Product Name

The data product name is WAVSTAT. There are many parameters within this data product, for which there are identifiers and descriptions in the following section.

2.2.2 Data Product Abstract (for Metadata)

This data product contains multiple parameters describing the surface wave statistics, including wave periods, heights, directions, spectral properties, and motion of the platform from which the measurements are made. The complete list of parameters is:

Data Product ID	**Alt. Notation**	**Description**
WAVSTAT-N0	N_0	Number of zero crossings in the underlying displacement data, used primarily for verification and QC
WAVSTAT-HMAX	H_{max}	Maximum wave height (units: m)
WAVSTAT-HAVG	H_{avg}	Average wave height (units: m)
WAVSTAT-TAVG	T_{avg}	Average wave period (units: s)
WAVSTAT-HSIG	H_{sig}	Significant wave height, average height of the highest third of the waves (units: m)
WAVSTAT-HMO	H_{mo}	Significant wave height estimated by an alternate method based on spectral moments (units: m)
WAVSTAT-TSIG	T_{sig}	Significant wave period, average period of the H_{sig} waves (units: s)

WAVSTAT-H10	H_{10}	Average height of the highest tenth of the waves (units: m)
WAVSTAT-T10	T_{10}	Average period of the H_{10} waves (units: s)
WAVSTAT-TP	T_P	Peak wave period; period where wave spectrum has its maximum (units: s)
WAVSTAT-TP5	T_{P5}	Peak wave period computed via Read method; an alternative to T_P (units: s)
WAVSTAT-D	D	Mean direction of wave field against true north (units: degrees)
WAVSTAT-DS	DS	Mean directional spread of wave field (units: degrees)
WAVSTAT-PND	$PND_{1..N}$	Power spectral density values for non-directional spectra in m^2 Hz^{-1}
WAVSTAT-FND	$FND_{1..N}$	Frequency values for non-directional spectra in units of Hz
WAVSTAT-FDS	$FDS_{1..N}$	Frequency values for directional spectra in units of Hz
WAVSTAT-PDS	$PDS_{1..N}$	Power spectral density values for directional spectra in units of m^2 Hz^{-1}
WAVSTAT-DDS	$DDS_{1..N}$	Direction of waves from directional spectra against true north in units of ° (degrees)
WAVSTAT-SDS	$SDS_{1..N}$	Direction spread from directional spectra in units of ° (degrees)
WAVSTAT-MOTX	X	Buoy displacement in eastward direction, in units of meters
WAVSTAT-MOTY	Y	Buoy displacement in northward direction, in units of meters
WAVSTAT-MOTZ	Z	Buoy displacement in upward direction, in units of meters
WAVSTAT-MOTT	t	Time corresponding to the WAVSTAT-MOTX, -MOTY, -MOTZ displacement data.

For the ADCPs that will be used to measure waves in addition to currents, RDI's WavesMon software produces output that can be mapped to output from the buoy-mounted WAVSS sensors. Using output format 9 (Table 10 in the WavesMon manual), WavesMon will output the following wave statistics:

Name	Units	Description	Equivalent to WAVSS
Burst	#	Burst number	
Date and time field	YY,MM,DD,HH,mm,ss,cc	Leading zeros are always included to maintain fixed length. YY = 2 fixed digits for year, MM= 2 fixed digits for month, and DD= 2 fixed digits for day. HH = 2 fixed digits of hours, mm = 2 fixed digits of minutes, ss = 2 fixed digits of seconds, and cc = 2 fixed digits of 1/100th seconds.	
Hs -	meters	Significant Wave Height	WAVSTAT-

Significant Wave Height			HSIG. See also WAVSTAT-HMO
Tp - Peak Wave Period	seconds	Period associated with the largest peak in the power spectrum	WAVSTAT-TP. See also WAVSTAT-TSIG, WAVSTAT-TP5
Dp - Peak Wave Direction	degrees	Peak direction at the peak period with respect to true North.	WAVSTAT-D
Tp_Sea	seconds	Period associated with the largest peak in the sea region of the power spectrum. (see Note in manual)	
Dp_Sea	degrees	Peak sea direction at the peak period in the sea region. (see Note in manual)	
Hs_Sea	meters	Significant Wave Height in the sea region of the power spectrum.	
Tp_Swell	seconds	Peak Swell Wave Period - period associated with the largest peak in the swell region of the power spectrum. (see Note in manual)	
Dp_Swell	degrees	Peak Swell Wave Direction - peak swell direction at the peak period in the swell region. (see Note)	
Hs_Swell	meters	Significant Wave Height in the swell region of the power spectrum.	
Depth Water level	millimeters	from pressure sensor	
Hmax	meters	Maximum wave height - as determined by Zero-Crossing analysis of the surface track time series.	WAVSTAT-HMAX
Tmax	seconds	Maximum Peak Wave Period - as determined by Zero-Crossing analysis of the surface track time series.	
H1/3	meters	Significant wave height of the largest 1/3 of the waves in the field as determined by Zero-Crossing analysis of the surface track time series.	
T1/3	seconds	The period associated with the peak wave height of the largest 1/3 of the waves in the field as determined by Zero-Crossing analysis of the surface track time series.	
Hmean	meters	The mean significant wave height	WAVSTAT-

		of the waves in the field as determined by Zero-Crossing analysis of the surface track time series	HAVG
Tmean	seconds	The period associated with the mean significant wave height of the waves in the field as determined by Zero-Crossing analysis of the surface track time series.	WAVSTAT-TAVG
H1/10	meters	Significant wave height of the largest 1/10 of the waves in the field as determined by Zero-Crossing analysis of the surface track time series.	WAVSTAT-H10
T1/10	seconds	The period associated with the peak wave height of the largest 1/10 of the waves in the field as determined by Zero-Crossing analysis of the surface track time series.	WAVSTAT-T10
Dmean	degrees	Mean Peak Wave Direction	
#	bins	Number of bins	
depthlevel1	m/s	Magnitude Depth Level 1 Magnitude	
depthlevel1	deg	Direction Depth Level 1 Direction	
↓			
depthlevelN	m/s	Magnitude Depth Level N Magnitude	
depthlevelN	deg	Direction Depth Level N Direction	

The outputs from the WAVSS instrument that are not output by WavesMon are:

Data Product ID	Alt. Notation	Description
WAVSTAT-N0	N_0	Number of zero crossings in the underlying displacement data, used primarily for verification and QC
WAVSTAT-DS	DS	Mean directional spread of wave field (units: degrees)
WAVSTAT-MOTX	X	Buoy displacement in eastward direction, in units of meters
WAVSTAT-MOTY	Y	Buoy displacement in northward direction, in units of meters
WAVSTAT-MOTZ	Z	Buoy displacement in upward direction, in units of meters
WAVSTAT-MOTT	t	Time corresponding to the WAVSTAT-MOTX, -MOTY, -MOTZ displacement data.

Like the WAVSS buoy-mounted instrument, directional wave spectra are output by WavesMon from raw ADCP data. See section 4.4 in the WavesMon manual for procedure and output format. WaveMon outputs directional spectrum in units of mm^2/Hz per cycle for each of 90 directions and 64 frequencies. It also outputs corresponding Fourier coefficients for those 64 frequencies. The 9 fields for each frequency are Frequency (Hz), Band width (Hz), Energy Density (m^2/Hz), Direction (deg), A1, B1, A2, B2, and check factor. Frequency bands are 0.015625 Hz wide with the first frequency band centered at 0.00830078 Hz.

For reference, the roughly equivalent data from the WAVSS instrument are:

Data Product ID	**Alt. Notation**	**Description**
WAVSTAT-PND	$PND_{1..N}$	Power spectral density values for non-directional spectra in $m^2\ Hz^{-1}$
WAVSTAT-FND	$FND_{1..N}$	Frequency values for non-directional spectra in units of Hz
WAVSTAT-FDS	$FDS_{1..N}$	Frequency values for directional spectra in units of Hz
WAVSTAT-PDS	$PDS_{1..N}$	Power spectral density values for directional spectra in units of $m^2\ Hz^{-1}$
WAVSTAT-DDS	$DDS_{1..N}$	Direction of waves from directional spectra against true north in units of ° (degrees)
WAVSTAT-SDS	$SDS_{1..N}$	Direction spread from directional spectra in units of ° (degrees)

2.2.3 Computation Name
n/a

2.2.4 Computation Abstract (for Metadata)
The WAVSS instruments perform all computations internally. See the instrument manual for further details on the computation.

2.2.5 Instrument-Specific Metadata
See section 4.4.

2.2.6 Synonyms
n/a

2.2.7 Similar Computations
Surface wave statistics are also calculated from data collected by acoustic Doppler current profilers (ADCP) mounted on the seafloor at the shallowest OOI sites. Data from these ADCPs are described in the VELPROF DPS document because these instruments also measure velocity profiles.

2.3 Instruments
Instrument class WAVSS.

2.4 Literature and Reference Documents

- DCN 1342-00450: Processing flow diagram for data products from the WAVSS class of instruments.
- Instrument manual: TRIAXYS™ OEM Directional Wave Sensor, User's Manual. AXYS Technologies Inc., Sidney, BC, Canada. May 2005.
- Teledyne RD Instruments (2011), WavesMon v3.08 User's Guide. P/N 957-6232-00
- Teledyne RD Instruments, Waves Primer: Wave Measurements and the RDI ADCP

Waves Array Technique

2.5 Terminology

2.5.1 Definitions

n/a

2.5.2 Acronyms, Abbreviations and Notations

General OOI acronyms, abbreviations and notations are contained in the Level 2 Reference Module in the OOI requirements database (DOORS). There are no other acronyms, abbreviations, or notations for this document.

2.5.3 Variables and Symbols

In addition to the ones given in section 2.2.2, the following variables and symbols are defined here for use throughout this document:

N:	Number of data points (exact meaning depends on context)
t:	Time
Δ_t, delta_t:	Time step, i.e. the time difference between successive measurements
Δ_F, delta_F:	The difference between successive frequency values

3 Theory

3.1 Description

The WAVSS instruments measure three-dimensional acceleration, rotation rate, and orientation in the magnetic field of the earth via a compass. From this, the motion of the sea surface in the wave field is reconstructed.

The instrument configuration is an important part of the metadata to be preserved together with the output data product. Details are listed in section 4.4.

The measurement is such that the instrument measures accelerations for a certain acquisition time interval (typically 20-30 minutes). Then, the wave properties are computed for this interval, i.e. there is one data value for each wave property representing the entire acquisition time interval. The actual time series resolving the instrument motion over the course of the acquisition interval can be computed as well.

The two TRDI ADCPs on Endurance Inshore Submersible Moorings will be used to measure surface waves, not just mean currents. Raw wave data are in the same PD0 format as current data, so VELPROF and ECHOINT data products may be calculated from these data in the same way as other PD0 data produced by this instrument. The difference in the raw currents and waves data are that the currents data are saved as ensemble averages (e.g., average values over a few minutes of water pings) while the waves data stores information from every ping so that wave orbital velocities can be calculated in post-processing. Typical surface wave periods are 5-20 seconds, so the ADCP must sample for wave orbital velocities every few seconds or more often, which is why every ping is saved instead of ensemble averages. This wave measurement method is used for just these two moorings because they are shallow enough for a bottom-mounted ADCP to accurately measure wave-driven currents and because the buoys on these two moorings are designed to submerge under crests of large waves to reduce tension on the mooring cable so a buoy-mounted wave sensor would not measure waves accurately.

3.2 Mathematical Theory

The computations to obtain the data values are done by proprietary software within the WAVSS instruments, i.e. not discussed here.

The theory for how wave statistics are calculated from RDI ADCPs is in the RDI Waves Primer and the WavesMon manual.

3.3 Known Theoretical Limitations

The instruments are mounted on large buoys, which in turn have additional structures above and below the water. This mechanical setup is not ideal for wave measurements, because the transfer function that relates the actual wave motion to the buoy motion is not well understood – i.e. the buoy setup filters some of the wave motion out of, or adds additional motion into, the accelerations that the instruments measure. This will degrade data quality. The OOI will maintain drawings and metadata that capture the mechanical setup of the instrument on the buoy platform in an attempt to document the problem, in the hope that this documentation may be useful for future improvement of the data product or analysis thereof.

Directional information is obtained from the compass within the instrument. Magnetic disturbance from onboard the platform or external sources (i.e. large ship or power cable nearby) will degrade the directional accuracy.

There are different methods to describe the wave properties in meaningful ways (see e.g. the difference between H_{sig} and H_{10}). It is not always obvious which property is best suited for a particular use.

3.4 Revision History

n/a

4 Implementation

4.1 Overview

Output data are extracted from the raw data streams directly. Except for reconstructing frequency values and time values from a start value and equal spacing, no further processing is needed, because the instruments perform the computations internally. For purposes of calculating true directions from the magnetic compass readings, adjustments are made for magnetic variation and deviation.

There are two potential sources of input data: the serial output of the instrument (typically used for near-real-time data transfer), and the data stored internally on a flash drive (typically available only after instrument recovery). This document describes both, as the data format is identical.

4.2 Inputs

4.2.1 Serial Line (Near Real-Time)

The instrument sends NMEA messages through the serial line when commanded to do so. There are different NMEA identifiers for different subsets of data, which can collectively be queried with the command "?MFB" on the serial line, including an instrument status report. The NMEA messages thus received serve as the input for this data product and contain the actual data available for near-real-time streams:

- $TSPWA messages for wave statistics
- $TSPNA messages for non-directional spectra
- $TSPMA messages for directional spectra
- $TSPHA messages for platform motion

In addition, the following NMEA messages exist:

- \$TSPSA messages containing instrument status
- \$TSPFA messages containing Fourier coefficients

The instruments can be configured to store only subsets of the above data; the standard operational modus within the OOI should be that all of these data are recorded.

4.2.2 Internally Logged File (Post-Recovery)

The instrument logs data internally on a flash drive, which can be removed from the instrument and read as per the instructions in the instrument manual. The data on the flash card is twofold: there is a binary raw file, and there are the NMEA messages in plain text files. For the purpose of this DPS, it is sufficient to use the NMEA message files and process them exactly as the near-real-time data streams. However, all of the files, including the binaries, should be stored as raw data within the OOI.

4.3 Processing Flow

- The following variables are extracted from the input (either serial line or internally logged file) and published directly as outputs: N_0, H_{max}, H_{avg}, T_{avg}, H_{sig}, H_{mo}, T_{sig}, H_{10}, T_{10}, T_P, T_{P5}, D, DS, $PND_{...}$, $PDS_{...}$, $DDS_{...}$, $SDS_{...}$.
- The frequencies for the non-directional spectra FND… are computed and published as an output:
  - Extract number of frequencies N, initial frequency FND_1 and frequency spacing delta_F from the input data for non-directional spectra (either serial line or internally logged file).
  - Compute $FND_{2..N}$ such that $FND_{i+1}=FND_i+$ delta_F
- The frequencies for the directional spectra FDS… are computed and published as an output:
  - Extract number of frequencies N, initial frequency FDS_1 and frequency spacing delta_F from the input data for directional spectra (either serial line or internally logged file).
  - Compute $FDS_{2..N}$ such that $FDS_{i+1}=FDS_i+$ delta_F
- Platform motion:
  - Extract X, Y, Z from input
  - Use 2-D rotation with input paramers X and Y, and operator-provided correction value for magnetic variation and deviation, to adjust X and Y
  - Publish X, Y, Z as output product
  - Derive time of first data point, t_1, from input data
  - Read number of data points N and time step delta_t from input
  - Compute time t and publish as output product (compute $t_{2..N}$ such that: $t_{i+1}=t_i+$ delta_t)
- Post-processing:
  - For the parameters D and DDS, run the following to allow adjustment of the directions for magnetic deviation and variation:
    - POLYVAL using the operator-provided correction value for input parameter P, and D and DDS as input parameter X, as applicable. If no correction value has been provided, use P=0.

    - MODULUS using input parameters Y=360, and X=D or X=DDS, as applicable.
  - Trigger automated QC checks for outputs.

For the ADCPs that will be used to measure waves in addition to currents, wave statistics should be calculated from raw ADCP PD0 format data by RDI's WavesMon software. The ADCP will output waves and currents data through the same serial port, and these data share the same output file format, so one must distinguish between data taken for these two different purposes. Wave statistics should be calculated on complete 20 minute segments of data, not on every ping. These ADCPs will collect 20 minute segments of data once every three hours to meet the pivotal sampling strategy. An ensemble of currents and backscatter (not suitable for calculating wave statistics) will be collected once an hour on the hour to meet the pivotal sampling strategy.

4.4 Outputs

See previous section: N_0, H_{max}, H_{avg}, T_{avg}, H_{sig}, H_{mo}, T_{sig}, H_{10}, T_{10}, T_P, T_{P5}, D, DS, $PND_{...}$, $FND_{...}$, $PDS_{...}$, $DDS_{...}$, $SDS_{...}$, $FDS_{...}$, X, Y, Z, t.

Metadata:

- Water depth (m)
- Start time of acquisition time interval (extracted from $TSPSA status message or logged data file, see instrument manual)
- Duration of acquisition time interval (extracted from $TSPSA status message or logged data file, see instrument manual)
- Magnetic variation and deviation used for adjusting the compass readings
- X, Y, and Z offsets programmed into the instrument – obtained via serial line command "?O" at least once during deployment (and before/after every configuration change)
- Link to engineering drawing(s) that identifies instrument mounting and orientation on platform, as deployed

See section 2.2 for outputs from the ADCPs used to measure wave statistics.

4.5 Computation and Numerical Considerations

. WavesMon software is needed to calculate wave statistics for the ADCPs used to measure wave statistics.

4.6 Code Verification and Test Data Sets

The following are test data of each NMEA message, as sent by the vendor in August 2012. Note that the number of decimal digits may vary, i.e. the decoding algorithm should operate by processing between comma symbols rather than by number of digits.

```
- Buoy Status ($TSPSA ?MNS)

$TSPSA,20120809,205936,04471,buoyID,,,+000.0,12.10,4.0,1200,60,60,1,04471,1.01.0648,3.2,8
9,0,0.000,+00.0,5*55


- Wave Statistics ($TSPWA ?MNW)

$TSPWA,20120809,205936,04471,buoyID,,,24,0.00,9.7,0.00,0.00,13.1,0.00,17.3,5.9,33.3,33.3,
0.00,308.2,46.9*5E
```

- Non Dirspec ($TSPNA ?MNN)

$TSPNA,20120809,205936,04471,buoyID,,,123,0.030,0.005,1.945E-06,4.843E-07,4.649E-
07,2.059E-07,2.057E-07,2.652E-08,2.973E-08,1.913E-08,4.111E-08,3.398E-08,2.246E-
08,1.411E-08,1.615E-08,2.020E-08,1.047E-08,2.255E-08,1.831E-08,4.427E-09,1.994E-
08,2.243E-09,6.367E-09,3.189E-09,3.120E-09,8.349E-10,4.121E-09,2.779E-09,1.102E-
09,3.530E-10,1.795E-09,4.449E-10,1.625E-09,2.480E-09,1.013E-09,1.323E-09,1.798E-
09,1.671E-08,3.653E-08,3.423E-08,1.963E-08,1.728E-08,3.160E-08,6.646E-08,4.118E-
08,5.824E-08,2.969E-08,1.600E-08,1.700E-08,3.032E-08,3.055E-10,3.308E-08,5.706E-
09,3.782E-09,1.241E-08,6.842E-09,2.928E-09,1.380E-08,2.341E-08,8.463E-09,1.340E-
08,1.284E-08,6.753E-09,6.516E-09,7.677E-09,1.007E-08,1.706E-08,7.672E-09,8.349E-
09,7.636E-09,7.303E-09,1.385E-08,7.326E-09,1.006E-08,3.947E-09,5.111E-09,9.264E-
09,1.453E-08,7.290E-09,1.390E-08,1.103E-08,2.585E-09,1.262E-08,1.188E-08,4.324E-
09,6.928E-09,3.997E-09,9.241E-09,3.416E-09,7.592E-09,4.856E-09,2.149E-09,5.373E-
09,2.265E-09,4.771E-09,4.612E-09,3.980E-09,5.825E-09,3.475E-09,1.806E-09,6.229E-
09,5.920E-09,2.463E-09,3.982E-09,5.167E-09,1.444E-09,2.101E-09,2.445E-09,8.411E-
10,7.001E-10,1.552E-09,1.647E-09,5.653E-10,2.824E-10,1.923E-09,3.652E-10,4.320E-
10,1.488E-09,5.452E-10,1.083E-09,9.857E-10,5.291E-10,3.220E-10,3.630E-11,7.446E-10*1C

- Mean Dir ($TSPMA ?MNM)

$TSPMA,20120809,205936,04471,buoyID,,,97,0.030,0.005,308.19,46.85,1.945E-
06,314.0,29.3,4.843E-07,319.8,45.3,4.649E-07,33.0,72.5,2.059E-07,270.1,72.8,2.057E-
07,282.4,75.3,2.652E-08,78.3,71.6,2.973E-08,75.3,67.0,1.913E-08,65.0,74.8,4.111E-
08,192.2,72.6,3.398E-08,253.6,75.6,2.246E-08,337.9,68.7,1.411E-08,239.1,71.1,1.615E-
08,220.6,67.2,2.020E-08,252.3,59.3,1.047E-08,242.3,63.8,2.255E-08,229.5,55.3,1.831E-
08,223.0,50.4,4.427E-09,202.2,65.8,1.994E-08,208.4,58.9,2.243E-09,210.6,56.6,6.367E-
09,214.2,58.0,3.189E-09,242.3,61.3,3.120E-09,276.5,74.0,8.349E-10,225.9,62.0,4.121E-
09,228.8,40.2,2.779E-09,238.0,37.8,1.102E-09,253.9,62.7,3.530E-10,223.5,49.2,1.795E-
09,245.8,47.3,4.449E-10,238.2,59.0,1.625E-09,218.6,62.8,2.480E-09,196.9,57.2,1.013E-
09,221.6,67.4,1.323E-09,197.3,61.5,1.798E-09,133.5,76.9,1.671E-08,258.9,56.3,3.653E-
08,241.6,53.6,3.423E-08,219.1,59.0,1.963E-08,245.1,68.5,1.728E-08,242.5,71.7,3.160E-
08,322.2,66.2,6.646E-08,355.7,51.7,4.118E-08,17.8,50.8,5.824E-08,16.9,45.6,2.969E-
08,216.8,70.0,1.600E-08,214.6,49.7,1.700E-08,239.6,58.0,3.032E-08,245.2,63.8,3.055E-
10,243.8,65.8,3.308E-08,245.5,61.5,5.706E-09,243.6,56.9,3.782E-09,141.5,74.7,1.241E-
08,331.8,73.5,6.842E-09,306.4,47.6,2.928E-09,254.9,51.6,1.380E-08,229.7,50.4,2.341E-
08,221.0,49.0,8.463E-09,209.8,41.8,1.340E-08,227.7,50.8,1.284E-08,252.1,57.1,6.753E-
09,233.8,58.6,6.516E-09,230.8,51.0,7.677E-09,252.2,46.0,1.007E-08,242.4,45.3,1.706E-
08,240.2,45.4,7.672E-09,237.7,48.9,8.349E-09,229.1,41.6,7.636E-09,232.3,32.2,7.303E-
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08,238.2,44.4,1.188E-08,239.3,45.1,4.324E-09,235.7,49.2,6.928E-09,236.8,46.4,3.997E-
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- Fourier ($TSPFA ?MNF)

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23,0.03303113,0.2133156,0.0285926,9.160382E-29,0.04201765,0.05248808,0.006102096,-
3.673009E-29,0.05254127,0.178191,-0.01586401,25374.69,0.06378684,0.06099645,-0.03570499,-
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- Heave North East ($TSPHA ?MNH)

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