FILE:SLA02_doc.rtf
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STRUCTURE: SLA02(MEGASTRUCTURE)

TP	**STRUCT**	**-> TIMEPArray[1]**
RP	**STRUCT**	**-> RANGEP Array[1]**
BP	**STRUCT**	**-> BOUNCP Array[1]**
PAP	**STRUCT**	**-> POSSATTP Array[1]**
EP	**STRUCT**	**-> ENGP Array[1]**
WAVGRP	**STRUCT**	**-> FWAV Array[1]**

STRUCTURE:SLA02.TP (TIME PARAMETERS GROUP)

TAG NAME	DESCRIPTION
MES*	Mission elapsed seconds computed with full corrections (in seconds)
LASTIME*	Laser shot time tag (in seconds)
SHUT_DIFF*	Difference of shuttle **MES** and **LASTIME** at minute pulse (in seconds)
MES_CORR*	Functional fit of **SHUT_DIFF** (data edited) evaluated at **LASTIME** for every shot (in seconds) **MES = LASTIME + MES_CORR**

STRUCTURE:SLA02.RP (RANGE PARAMETERS GROUP)

TAG NAME	DESCRIPTION
RANGE_CORR*	SLA range corrected for troposphere delay (assuming standard atmosphere) and SLA range bias (meters).

STRUCTURE:SLA02.BP (BOUNCE-POINT PARAMETERS GROUP)

TAG NAME	DESCRIPTION
LAT*	Geodetic Latitude of geolocated shot bounce-point (in degrees North or South) in Topex/Poseidon (T/P) ellipsoid reference frame which is essentially identical to WGS-94 ellipsoid. Defined as the acute angle between the semi-major axis and the line through the observer perpendicular to the spheroid.
LON*	Geodetic Longitude of geolocated shot bounce-point (in degrees East) in T/P ellipsoid reference frame, essentially identical to WGS-94 ellipsoid. Defined as the angle measured eastward in the equatorial plane between the Greenwich meridian and the observer's meridian.
ELLIP_HT*	Ellipsoid height of the geolocated shot bounce-point (in meters), perpendicular to the reference ellipsoid, in T/P ellipsoid reference frame, essentially identical to WGS-94 ellipsoid.
SURFACE_1*	Ocean Surface Model (in meters); Ohio State University 95 (OSU95) Mean Sea Surface (MSS).
SURFACE_2*	Time varying ocean surface correction (in meters); Ray Pathfinder Ocean Tide Model.
SURFACE_3*	Smoothed residuals of SLA to Ocean Surface difference (in meters). **SURFACE_3 = SURFACE_1 + SURFACE_2 - ELLIP_HT** (smoothed)
GEOID*	Geoid undulation at shot bounce-point (NASA/NIMA Earth Geoid Model-96; EGM-96) (in meters).
ORTHO_HT*	Orthometric Height (in meters). Includes SURFACE_3 correction (linearly extrapolated from ocean residuals)

ORTHO_HT = ELLIP_HT + SURFACE_3– GEOID

STRUCTURE:SLA02.PAP (POSITION AND ATTITUDE PARAMETERS GROUP)

TAG NAME	DESCRIPTION
SATHT*	Ellipsoid satellite height (Center of Mass) (in meters) in T/P ellipsoid reference frame, essentially identical to WGS-94 ellipsoid.
ECFX_SHOT*	Earth Centered Fixed X-coordinate of shot bounce point (in meters)
ECFY_SHOT*	Earth Centered Fixed Y-coordinate of shot bounce point (in meters)
ECFZ_SHOT*	Earth Centered Fixed Z-coordinate of shot bounce point (in meters)
AZIMUTH*	Degrees from true North of laser vector (0 to 360 clockwise from North)
AOFFNADIR*	Degrees from Nadir of laser vector (0 = Nadir, 90=Horizontal)

STRUCTURE:SLA02.EP (ENGINEERING PARAMETERS GROUP)

TAG NAME	DESCRIPTION
XMIT_EN*	Transmit energy (counts, not calibrated)
RECEIVE_EN*	Received energy on channels 1, 2, 3 (counts, not calibrated)
THRESH*	Detection threshold level on channels 1, 2, 3. Array of 3 thresholds for the 3 differently filtered channels. (counts, not calibrated)
CHANNEL*	Which was the fastest channel triggered, defining which channel was used to measure the range. Channel 1 = 16.6 MHz (intermediate filter) Channel 2 = 5.8 MHz (slowest filter) Channel 3 = 32 MHz (fastest filter) Channel 4 ranging was disabled.
WAVE_OFFSET*	Offset applied when reading from digitizer memory to ensure that the stop pulse, defined when the leading edge of the received signal exceeds the detection threshold, is contained within the stored waveform. A variable depending on which was the fastest channel triggered. (counts, not calibrated)
VGA*	Variable Gain Attenuator setting for the detector sensitivity (Bytes). A measure of the DC voltage applied to the VGA. **VGA** control Volts = **VGA** (bytes) * 20.0/1000.0
DIGI_ATTEN*	Digitizer Attenuator Setting (dB).
SCALE_FACTOR*	Waveform Amplitude Scale Factor (Unitless). Waveform Amplitude Scale Factor = Detector Scale Factor (Unitless) * Digitizer Scale Factor (Unitless) Digitizer Scale Factor = invlog [**DIGI_ATTEN** (in dB) /(-20.0)] (Unitless) Detector Scale Factor = invlog [Detector Attenuation (in dB) /(-20.0)] (Unitless) Detector Attenuation (in dB) = (detector gain at VGA control voltage)/(detector gain at reference VGA control voltage) (Detector Attenuation (dB) versus VGA control voltage established by pre-flight calibration) Non-attenuated Waveform Amplitude (in counts) = Recorded Waveform Amplitude (in counts) * Waveform Amplitude Scale Factor

STRUCTURE:SLA02.EP (ENGINEERING PARAMETERS GROUP) (cont.)

TAG NAME	DESCRIPTION
PWIDTH*	Electronic Pulse Width (counts, not calibrated). Duration that the Channel 1 received energy exceeded the Channel 1 threshold.
AVERAGE*	Software equivalent of a digitizer divider. The two channels (A & B) of the digitizer each sample at a MHz rate established by adjustable parameters (**DIGI_CLOCK** and **DIGI_DIV**). The two channels where then either recorded separately and stored in even and odd bin positions in the **WAVEFORM** array, or averaged together before storing as a single waveform bin value: = 1 for internal, averaging implemented (almost always the case) = 0 for external, no averaging
BIN_SIZE*	Round-trip (i.e., two-way) travel time duration of digitizer bin (in nanoseconds). Time between samples for the digitizer. Speed of light = 299792458.0d-09 (m/nsec) **One-way BIN_SIZE (m) = BIN_SIZE (nsec) * (299792458.0d-09 / 2.) (m/nsec)**
WAVEFORM*	Array[150] of raw digitizer bin values (in byte counts)

STRUCTURE: SLA02.WAVGRP (SHOT CLASSIFICATION AND WAVEFORM PROCESSING PARAMETERS GROUP, ONLY RTYP=15, 25)

**** Structure FWAV, 5 tags, length=108**

BL	**STRUCT**	**-> BASLIN Array[1]**
WF	**STRUCT**	**-> WVFRM Array[1]**
EN	**STRUCT**	**-> ENVRN Array[1]**
CL	**STRUCT**	**-> CLASS Array[1]**
GM	**STRUCT**	**-> GMOD Array[1]**

STRUCTURE:SLA02.WAVGRP.BL (BASELINE PARAMETERS GROUP)

(digitizer noise characterization)

TAG NAME	DESCRIPTION
NPOINTS*	Number of bins at the start of the waveform used to define the noise baseline.
MEAN*	Mean of the noise baseline (in raw digitizer counts).
SIG*	Standard deviation of the noise baseline (in raw digitizer counts).

STRUCTURE:SLA02.WAVGRP.WF (WAVEFORM PARAMETERS GROUP)

TAG NAME	DESCRIPTION
START*	Position of the first bin in the waveform where the signal increases above **MEAN + SIG**
NPOINTS*	Width of the signal (in bins). Defined as the number of bins from **START** to the last bin where the signal falls below the amplitude level of the **START** bin.
MAX*	Maximum digitizer return signal (non-attenuated waveform amplitude counts)
WIDTH*	Width (in nanoseconds) = **NPOINTS * BIN_SIZE**
AMPLITUDE*	Maximum amplitude – noise baseline mean = **MAX – MEAN** (non-attenuated waveform amplitude counts) (**AMPLITUDE** is zero referenced; baseline mean is subtracted to account for offset amplitude added to entire waveform after application of detector and digitizer scale factors)
AREA*	Area under the waveform signal above the noise baseline mean from **START** to **START + NPOINTS** (non-attenuated waveform amplitude counts * nanoseconds)

STRUCTURE: SLA02.WAVGRP (SHOT CLASSIFICATION AND WAVEFORM PROCESSING PARAMETERS GROUP)(cont.)

STRUCTURE:SLA02.WAVGRP.WF (WAVEFORM PARAMETERS GROUP) (cont.)

TAG NAME	DESCRIPTION
MMNT*	Moments of the signal above the baseline mean from **START** to **START + NPOINTS.** **MEAN** centroid of the distribution of return signal power (nsec), relative to **START** of signal above noise. **SIG** 1 sigma deviation of the distribution (nsec). **SKEW** skew of the distribution (unitless). **KURT** kurtosis of the distribution (unitless).
NMAX*	number of Gaussian peaks fitted to waveform between **START** and **START + NPOINTS.** (Based on identification of maxima from first and second derivatives and subsequent optimization of least-squares fitting of **NMAX** Gaussian distributions to signal above baseline mean.)

STRUCTURE: SLA02.WAVGRP (SHOT CLASSIFICATION AND WAVEFORM PROCESSING PARAMETERS GROUP)(cont.)

STRUCTURE:SLA02.WAVGRP.EN (BOUNCE-POINT ENVIRONMENT PARAMETERS GROUP)

(SEE APPENDED NOTES FOR INFORMATION ON EXTERNAL DATA SETS)

TAG NAME	DESCRIPTION
DEM*	Elevation from Terrain Base 5 minute resolution Digital Elevation Model (in meters above Mean Sea Level, **DEM** = 0 for water) derived by bi-linear interpolation at the bounce point location using the four closest Terrain Base grid cells.
NDVI1*	Normalized Difference Vegetation Index (**NDVI**, from Global Land Advanced Very High Resolution Radiometer (AVHRR) Pathfinder project. Values range from –1 to 1, interpolated from a global composite grid at the location of the SLA bounce point.
NDVI2*	**NDVI** value from a 10-day composite corresponding to the closest available period to the STS-85 Mission (August11-20, 1997). (Not yet provided)
LANDCOVER*	Global land cover classification from satellite data (ISLSCP).
SLOPE*	Slope magnitude computed from **DEM** (in meters). (Not yet provided)
ROUGHNESS*	Surface roughness (relief) from **DEM** (in meters). (Not yet provided)

STRUCTURE: SLA02.WAVGRP (SHOT CLASSIFICATION AND WAVEFORM PROCESSING PARAMETERS GROUP) (cont.)

STRUCTURE:SLA02.WAVGRP.CL (WAVEFORM CLASSIFICATION PARAMETERS GROUP)

TAG NAME	DESCRIPTION
RTYP*	Return type **Ocean Returns** (defined to be where **DEM** = 0.) 21 = No range over ocean 22 = Noise above range gate over ocean 23 = Noise above clouds (**ORTHO_HT** >10,000 m) over ocean 24 = Clouds or noise above ocean surface (**ORTHO_HT** > 20 m) 25 = Surface return from ocean (**ORTHO_HT** within +/- 20 m) 26 = Noise below the ocean surface (**ORTHO_HT** < -20 m) 27 = Noise below the range gate over ocean **Land Returns** (defined to be where DEM > 0.) 11 = No range over land 12 = Noise above range gate over land 13 = Noise above clouds (**ORTHO_HT** >10,000 m) over land 14 = Clouds or noise above land surface (**ORTHO_HT-DEM** > 500 m) 15 = Surface return from land (ABS(**ORTHO_HT-DEM**) <= 500 m) 16 = Noise below land surface (**ORTHO_HT-DEM**) < -500 m) 17 = Noise below the range gate over land
STYP*	Saturation class (5 categories) 0 = no saturation 1 = near saturation 2 = linear saturation (slightly saturated waveform that can be treated as non-saturated waveform)

STRUCTURE: SLA02.WAVGRP (SHOT CLASSIFICATION AND WAVEFORM PROCESSING PARAMETERS GROUP) (cont.)

STRUCTURE:SLA02.WAVGRP.CL (WAVEFORM CLASSIFICATION PARAMETERS GROUP)(cont.)

TAG NAME	DESCRIPTION
STYP*	Saturation class (5 categories) 3 = non-linear saturation (type I) (deeply saturated) 4 = non-linear saturation (type II) (in fact not a saturation case, but a dip artifact in large peaks caused by stuck bit on one of the digitizer channels)
DTYP*	Digitizer jitter class (4 categories) (Not yet provided)
RMS*	Pulse spreading measured as the RMS roughness of the signal above the baseline mean from **START** to **START** + **NPOINTS** (in meters, for one-way travel distance after multiplying by Speed of Light (m/nsec) / 2.)
ASPECT*	A measure of pulse broadening = **AMPLITUDE / WIDTH**
LP_CENTROID*	Distance from signal **START** to centroid of the last maximum derived from Gaussian fits (in meters, for one-way travel distance after multiplying by Speed of Light (m/nsec) / 2.) (equal to wv_centroid if only one maximum found)
WV_CENTROID*	Distance from signal **START** to centroid of full waveform (in meters, for one-way travel distance after multiplying by Speed of Light (m/nsec) / 2.)

STRUCTURE: SLA02.WAVGRP (SHOT CLASSIFICATION AND WAVEFORM PROCESSING PARAMETERS GROUP) (cont.)

STRUCTURE:SLA02.WAVGRP.GM (GAUSSIAN FIT TO WAVEFORMS PARAMETERS GROUP)

(Gaussian fit of last maximum of multi-maxima waveform, or the one maximum of a single-maximum waveform)

TAG NAME	DESCRIPTION
CFFLAG*	Flag indicating convergence status of least-squares Gaussian fitting routines model. **0** Convergence occurred before 40 iterations. **1** Failed to converge by 40th iteration; best fit results reported. **2** Shot not processed, due to several possible reasons: - Range = 0. - Maximum amplitude of raw waveform < 15 byte counts - Maximum amplitude of scaled waveform < 1000 non-attenuated waveform amplitude counts - No baseline found to define background noise - Number of bins in signal (**NPOINTS**) < 5 or > 100 - More than 10 maxima found
G0*	Amplitude of Gaussian fit to last maxima, in scaled units (non-attenuated waveform amplitude counts).
G1*	Position of Gaussian fit to last maxima, as distance from **START** to center of last peak, in meters (based on 1-way **BIN_SIZE**). (same as **LP_CENTROID**, since only last peak parameters are stored)
G2*	Width of Gaussian fit to last maxima, as 1 sigma variance, in meters (based on 1-way **BIN_SIZE**).
CHISQ*	Chi-square value of least-squares Gaussian solution (square of the differences between the summation of the Gaussian fits to all maxima (**NMAX**) and the scaled waveform signal).
NITR*	Number of iterations needed for convergence (Maximum number of iterations allowed = 40).

Notes:

Sources for Environmental Parameters provided:

These data sets can be retrieved from the Earth Resources Observations Systems (EROS) Data Center Distributed Active Archive Center (EDC DAAC).

URL: http://edcwww.cr.usgs.gov/landdaac

DEM Source Data:

National Geophysical Data Center **TerrainBase**, 5 minute Global DTM Version 1.0 TBASE.BIN.
Area Coverage: Worldwide (90N to 90S x 180W 180E). Bathymetry was set to zero in SLA data set, reporting only interpolated elevations at the bounce point locations over land.

URL: **http://zenith.ngdc.noaa.gov/seg/fliers/se-1104.shtml**

Land Cover data:

Global land cover classification from satellite data (**ISLSCP**).

URL: **http://edcwww.cr.usgs.gov/landdaac/glcc/glcc.html**

Parameter/Variable Description			Range	Units	Source
LAND_COVER_CLASSIFICATIONS					
Value	Land Cover class		Min = 0 Max = 15	Not Applicable	DeFries & Townshend
0	0	water			
1	1	broadleaf evergreen forest			
2	2	broadleaf deciduous forest and woodland			

ISLSCP classification (cont.)

Parameter/Variable Description			Range	Units	Source
LAND_COVER_CLASSIFICATIONS					
Value		Land Cover class	Min = 0 Max = 15	Not Applicable	DeFries & Townshend
3	3	mixed coniferous and broad-leaf deciduous forest and woodland			
4	4	coniferous forest and woodland			
5	5	high latitude deciduous forest and woodland			
6,8	6	wooded c4 grassland			
7	6	c4 grassland			
9	7	shrubs and bare ground			
10	8	tundra			
11	6	desert, bare ground			
12	9	cultivation			
13		ice			
14	9	c3 wooded grassland			
15	9	c3 grassland			

NDVI source data characteristics:

URL: http://edcwww.cr.usgs.gov/landdaac/1KM/data_access.html

The original data set included values between 10 and 210, shifted and scaled from real values between –1 and 1). Values from 0 to 9 had been reserved for special masks (water, Goode's interrupted area, no data, etc). To accomplish this, a shift value is added to each pixel prior to scaling.

Equations for scaling and un-scaling values:

scaled = (actual + shift) * scale + offset
actual = (scaled - offset) / scale - shift

Masks used in shifted and scaled source:
0 = Missing Data Over Land
1 = Ocean
2 = Goode's Interrupted Area
3 = Solar Zenith angle greater than 80 degrees

The shifted and scaled source file values were converted to NDVI values using:
scale = 100
offset = 10
shift = 1

The source file was first projected from the Goode's projection to latitude and longitude and then sampled by bi-linear interpolation at the SLA bounce point location. During the interpolation:
If one or two of the four cells used for interpolation had one of the mask values, the NDVI value for the point was calculated as the average between the NDVI values from the valid cells.
If three of the cells corresponded to the same mask value, then the NDVI was set to that mask value. Otherwise, the value of -79.999 was returned.
After interpolating, masks values were set to:
-99.999 = no data over land
-9.999 = ocean
-69.999 = Goode's projection interrupted area
-59.999 = solar zenith >80
-79.999 = point not averaged nor interpolated in interpolation routine