University of Michigan
Space Physics Research Laboratory

TIDI Data Processing Software **Line of Sight File Format**	CAGE No. 0TK63 Drawing No. 055-4191 Project TIDI Contract No. NASW-5-5049 Page 1 of 1

REVISION RECORD

Rev	Description	Date	Author
Q	• Added 2 processing status bits to Table 8. (Bits 27 & 28)	3 Apr 2008	MLC
P	• Added the variable 'zero_corr' to Table 6 and changed the description of the variable 'zero_wind' in that same table.	20 Feb 2008	MLC
O	• Added 9 processing status bits to Table 8. (Bits 18-26) • Added 5 new global attributes to Table 2. • Added 6 new dimension variables in Table 3.	18 Oct 2007	MLC
N	• Added 2 processing status bits to Table 8. (Bits 16 and 17) Modified description of the processing status bit 15 in Table 8.	23 Jan 2007	MLC
M	• Added 6 processing status bits to Table 8. (Bits 9-15)	3 Apr 2006	MLC
L	• Added a processing status bit to Table 8. (Bit 8)	8 Dec 2004	MLC
K	• Added a processing status bit to Table 8. (Bit 7)	12 Apr 2004	MLC
J	• Minor changes with formatting and wording of paragraphs. • Added rotational temperature to LOS record table • Changed units on bspec to counts/sec • Retrieved values may be negative • Added table to describe named dimensions. • Added filter wheel configuration table	8 Dec 2003	MLC DAG
I	• Added a processing status bit to Table 8. (Bit 6)	10 Nov 2003	MLC
H	• Added more processing status bits to Table 8. (Bits 2 to 5)	9 Oct 2003	MLC
G	• Correct type of data_product_version from integer to string	22 Aug 2003	DAG
F	• Added number of iterations for the spectra fit. [fit_niters] • Changed 'rmbk' to 'back' in the diagnostic variables • Added the background removed spectra to the diagnostic variables. [LOS-TEST]	16 Jun 2003	MLC
E	• Merge LOS and RAW-LOS data • Indicate that all integers are signed integers. • Change version information to comply with convention	6 Jun 2003	DAG
D	• The minimum value of the index items, table_index and spec_index is 1. Ranges modified to emphasize this	17 Jan 2003	DAG
C	• Added definitions of the netCDF dimension variables • Added additional p_status interpretation information	19 Dec 2002	DAG
B	• Added definition of 'p_status' variable (Section 3.2.2.2).	3 Nov 2002	MLC
A	• Added 'pvat_filename' to global attributes, Table 2. • Changed data type of several of the variables to match what's actually in the output data file. • Removed variables 'lc and 'var_lc'. • Changed variable names tp_ilat, sc_ilat and zero_wind_pos to tp_mlat, sc_mlat and zero_wind respectively. • Clarified the description of version control RevIDs.	18 Jul 2002	MLC
	Initial Release	19 Jun 2002	DAG

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1. References

1. Gell, David "Downlink Software Development Plan", SPRL File 055-3439

2. Russ Rew, Glen Davis, Steve Emmerson, and Harvey Davies, *NetCDF User's Guide for C, Version 3*, Unidata Program Center, June 1997

3. APL, *TIMED General Instrument Interface Specification (GIIS),* APL File 7363-9050, 1 Oct 1997

4. Gell, David, "File Naming Convention Summary", SPRL File 055-3545

5. Gell, David, "Line of Sight File Format (Versions A and B)", SPRL File 055-3531

6. Seidelmann, P. Kenneth, USNO, Editor, *Explanatory Supplement to the Astronomical Almanac*", Sausalito, CA, University Science Books, 1992

2. Introduction

The TIDI Line of Sight (LOS) Data File contains the results of the line of sight retrieval program, RETRIEVE, (reference 1). This program consumes level 0 TM packets and produces this level 1b file. During flight operations the level 0 data from which this file is produced is formed from recorder playback data. During algorithm development, the level 0 data is produced by simulators or emulators.

This document specifies the format and content of the C and subsequent versions of the LOS file. A variant LOS file containing additional diagnostic information is also specified.

LOS files will generally contain data for an approximately 24 hour period beginning at 00h02 UTC and ending around 00h10 UTC of the following day. However, simulated and test data may be produced for shorter periods starting at arbitrary times.

3. File Organization and Content

Line of Sight Data will be stored in NetCDF (ref. 2) files. These files are organized as if they contained a series of arrays, one array for each data item. In addition to the data, a NetCDF file contains attributes. These attributes may be attached to a data item or they may be global, applying to the entire file. The minimum set of global attributes to be specified for the file is defined in an Appendix of the GIIS (ref. 3). The global attributes for this file are specified in section, 3.1 below

Attributes attached to each data item will include units, long name (description), maximum valid value, minimum valid value and missing value, as appropriate. The attributes and their definitions are specified in Table 1. The values used for the attributes are specified in subsequent sections. However when using the NetCDF file data, it is best to obtain the missing value and range for each variable by reading the appropriate attribute, as that information is always reliable.

Table 1, Data Item Attributes	
attribute name	*description*
`units`	a string containing the SI standard abbreviations for the units associated with the data item
`long_name`	a string containing a description of the data item, sufficiently detailed that a knowledgeable outsider can interpret the description
`valid_min`	the minimum value ever expected of the data item
`valid_max`	the maximum value ever expected of the data item
`missing_value`	a value either greater than valid_max or less than valid_min used to fill the data item in the absence of valid data. Missing values for variance quantities will be negative.

These files consist of two logical segments, a "header" consisting of the global attributes and the data records. The minimum contents of the header are specified in an Appendix of the GIIS (ref.3). The data section consists of two sets of data, the binning tables encountered during the data processing and the retrieved data records.

3.1. *File Header*

The global attributes which constitute the header of the line of sight file are listed in Table 2 , below. These attributes include those required by the GIIS and some TIDI unique items. The column labeled "Attribute Name" specifies the exact name to be used for the global attribute. The column labeled "Type" specifies whether the attribute is a character string, an integer number or a floating point number. In this column, items labeled Rev ID are a string consisting of a major revision number and a minor revision number separated by a decimal point. In the column labeled "Description", items in **`bold courier`** type are the exact constant value to be assigned to the attribute.

Table 2, Global Attributes		
Attribute Name	*Type*	*Description*
`title`	String	text description of the data file
`data_product_type`	String	**`ROUTINE, LEVEL1B`**
`mission`	String	**`TIMED`**
`source`	String	**`TIDI_POC`**
`data_product_version`	String	Version of the data product contained in the file. The version is a three digit number starting at 001 and incremented each time the data file is regenerated.
`product_format_version`	Rev ID	Version of the file format. The major format is incremented whenever the major software version number is incremented. The minor version number will be incremented whenever a variable is added or removed from the file format.
`software_version`	Rev ID	Major and Minor version numbers of the software used to produce the file. The major version number is incremented whenever there is a major change to the program that will likely affect the quality of the data product. The minor version number in incremented for bug fixes, interface changes or other changes that do not substantially change the quality of the data.

Table 2, Global Attributes

Attribute Name	*Type*	*Description*
software_name	String	**RETRIEVE**
calibration_version	String	The string "check CPF file name" for the version. We do not have a calibration that can be versioned with RevID.
filename	String	The name assigned to this file at the time of its creation.
input_file	String	The name of the TM Packet (level 0) file processed to create this file.
cpf_filename	String	CPF filename used in the processing of the LOS file.
pvat_filename	String	PVAT filename used in the processing of the LOS file.
date_created	String	yyyydoyhhmmss
magnetic_latitude_model	String	name of the magnetic model used to determine invariant latitude and magnetic longitude
solar_beta_angle	F4	The angle, in degrees, between the Earth-sun line and the orbit plane at 12:00 UT on the first date in the file. Positive values indicate that the spacecraft is flying forward, negative values indicate backwards flight.
att_s_var	F4	The estimated wind variance due to spacecraft attitude uncertainty in m^2s^{-2}
att_h_var	F4	The estimated tangent point altitude variance due to spacecraft attitude uncertainty in km^2
background_file	String	File that contains all the backgrounds taken during this day.
fit_variables	String	Variables and their values that are used for fitting the spectra. (fit_spectrum.F)
os_type	String	The operating system that the file was created on.
hostname	String	The actual machine name used for processing the file.
xtalk_filename	String	The name of the cross talk file that was used in normalizing the spectra. (normalize_spectra.F)

The date created field contains the time that the file was created, expressed in the TIMED standard ASCII format with fractional seconds omitted.

3.2. Data Segment

The data segment consists of a set of binning tables, described in section 3.2.1, a set of LOS data records described in section 3.2.2. and spectra described in section 3.2.3. Additional diagnostic information is described in section 3.3 may be included, in which case the file is an LOS-TEST file.

In Table 4, Table 6 and Table 9, which specify the contents of the binning tables, LOS data and spectra data, the columns specify the attributes of the data item. The short name is to be used as the variable name for the data item. The description is the string to be used as the NetCDF `long_name` attribute. The units column specifies the string to be used as the NetCDF `units` attribute. The type column indicates the type of the variable, where I indicates a signed integer type, C a character type and F a floating point type. The suffix digit indicates the length. A short integer in this notation is I2 and a single precision floating point number is F4. Arrays are dimensioned as shown in the dimension column. The range column defines a range of valid values for each item. These values shall be used as the `valid_min` and `valid_max` NetCDF attributes. The value for the `missing_value` attribute shall be outside of the valid range and is indicated in parenthesis following the range. Missing values specified for variance quantities shall be negative.

In a netCDF file, the dimensions of an array are contained in named dimension variables. The dimension variables are listed and defined in Table 3.

Table 3, Dimension Names

dimension variable	*usage*
`nb`	The number of binning tables contained in the file
`nbins`	The maximum number of spectral bins that may be included in a scene
`nfov`	The number of scenes
`nlos`	The record dimension of the LOS records. The number of lines of sight in the file.
`date_len`	The length of the ut_date character string
`onechar`	The length of a one character string
`eci_len`	The number of elements in an eci position vector, 3.
`shorts_per_spectrum`	The number of elements in a contamination bit map array
`nrecs_size`	The number of data records in the file.
`spec405_dim`	The number of channels in the calibration scene of the CCD.
`spec045_dim`	The number of channels in the scene for telescope 1.
`spec135_dim`	The number of channels in the scene for telescope 2.
`spec225_dim`	The number of channels in the scene for telescope 3.
`spec315_dim`	The number of channels in the scene for telescope 4.

3.2.1. Binning Tables

The five CCD binning pattern variables are defined in Table 4. The three three-dimensional arrays are organized by table, bin, and scene. These arrays are of the same dimensions; corresponding entries in each array refer to the same bin and binning table. Entries contain the starting and ending location of the bin in pixels from the apex and the bin's gain in electrons per count. The scene index specifies the telescope or calibration field as noted in Table 5.

Two additional arrays are defined. One is organized by binning index and scene and contains the number bins in each field. The other is organized only by the binning index. This array contains the binning table identification number.

Table 4, Binning Table Record Contents

short name	*Description*	*units*	*type*	*dim.*	*range (missing)*
bin_table_id	binning table identification number	number	I4	10§	x > 0 (-99)
initial_pixel	first pixel contained in a wavelength bin	pixel	I4	10§, 75†, 5‡	x > 0 (-99)
final_pixel	last pixel contained in a wavelength bin	pixel	I4	10§, 75†, 5‡	x > 0 (-99)
gain_values	nominal gain of bin	e^{-}/count	I4	10§, 75†, 5‡	5 ≤ x ≤ 160 (-99)
field_size	the number of wavelength bins in each field	number	I4	10§, 5‡	0 ≤ x ≤ 256 (-1)

§`nb:` The number of binning tables contained in the file
†`nbins:` The maximum number of spectral bins that may be included in a scene
‡`nfov:` The number of scenes (fields of view)

Table 5, Scene Identifiers

Index	*Scene*	*Azimuth*
1	calibration	405°
2	telescope 1	045°
3	telescope 2	135°
4	telescope 3	225°
5	telescope 4	315°

3.2.2. LOS Data Records

The LOS data records consist of one record for each measurement. The record contains apparent line of sight wind, temperature, volume emission rate, and continuum background retrieved from the spectra. It also contains ancillary data describing the state of the instrument at the time of the measurement, the location of the tangent point and indicators of the magnitude of dark count and radiation background correction.

The data are stored as a series of parallel arrays. The first dimension of each array is the record dimension and is omitted from the dimension column in Table 6. Vector items, such as the ECI position, are denoted in the table as having a dimension greater than 1 and are implemented as 2 dimensional NetCDF arrays with dimension (unlimited,n) where n is the value in the column labeled dim. Scalar items, such as tangent point longitude, are denoted in the table as having a dimension of 1 and are one dimensional NetCDF arrays with an unlimited dimension.

Table 6, LOS Record Contents

short name	*Description*	*units*	*type*	*dim.*	*range (missing)*
time	date and time of the measurement	s since epoch[1]	I4	1	x > 0 (-1)
ms_time	fractional second of the measurement	ms	I2	1	0 ≤ x < 1000 (-1)
ut_date	date of measurement, as a string in the form of YYYYdoy		C7	1	"1999001" ≤ x ≤ "2999366" ("1999000")
ut_time	universal time of measurement	ms	I4	1	0 ≤ x ≤ 86400000 (-1)
rec_index	count of record in file	—	I4	1	x ≥ 1 (0)
tp_lat	tangent point geodetic latitude	deg	F4	1	|x| ≤ 90 (-99)
tp_lon	tangent point east longitude	deg	F4	1	0 ≤ x ≤ 360 (-99)
tp_alt	height of the tangent point above the wgs 84[2] reference Earth (Ref 6)	km	F4	1	0 ≤ x ≤ 10000 (-99)
tp_lst	local solar time at the tangent point	hr	F4	1	0 ≤ x ≤ 24 (-99)
tp_sza	solar zenith angle at the tangent point	deg	F4	1	0 ≤ x ≤ 180 (-99)
tp_sscat	solar scattering angle at the tangent point	deg	F4	1	0 ≤ x ≤ 180 (-99)
tp_lza	lunar zenith angle at the tangent point	deg	F4	1	0 ≤ x ≤ 180 (-99)
tp_lscat	lunar scattering angle at the tangent point	deg	F4	1	0 ≤ x ≤ 180 (-99)
tp_mlat	magnetic latitude at the tangent point	deg	F4	1	|x| ≤ 90 (-99)
tp_mlon	magnetic longitude at the tangent point	deg	F4	1	0 ≤ x ≤ 360 (-99)
tp_track	track angle assigned to the tangent point, 360° at the first ascending node within the file	deg	F4	1	x ≥ 0 (-99)
tp_eci	x, y and z components of the tangent point position in the ECI coordinate frame	km	F4	3	$\|x\| \leq 10^4$ (-99999)
sc_eci_pos	x, y, and z components of the spacecraft position in the ECI coordinate frame.	km	F4	3	$\|x\| \leq 10^4$ (-99999)

[1] epoch is the GPS epoch, 00h00 UTC, 6 January 1980
[2] wgs 84: Equatorial Radius (R_e)=6738.137km, Inverse Flattening (1/f)=298.257223563

Table 6, LOS Record Contents					
short name	*Description*	*units*	*type*	*dim.*	*range (missing)*
sc_eci_vel	x, y, and z components of the spacecraft velocity in the ECI coordinate frame	km s^{-1}	F4	3	$-20 \leq x \leq 20$ (-99)
sc_vlos	the component of the spacecraft velocity in the instrument line of sight direction	m s^{-1}	F4	1	$\|x\| \leq 10^4$ (-99999)
var_sc_vlos	variance of the spacecraft velocity line of sight component due to attitude uncertainties	m^2 s^{-2}	F4	1	$0 \leq x \leq 10^4$ (-99)
sc_lat	spacecraft geodetic latitude	deg	F4	1	$-90 \leq x \leq 90$ (-99)
sc_lon	spacecraft east longitude	deg	F4	1	$0 \leq x \leq 360$ (-99)
sc_alt	height of the spacecraft above the wgs 84 reference Earth	km	F4	1	$0 \leq x \leq 10^4$ (-99)
sc_lst	local solar time at the spacecraft	hr	F4	1	$0 \leq x \leq 24$ (-99)
sc_sza	solar zenith angle at the spacecraft	deg	F4	1	$0 \leq x \leq 180$ (-99)
sc_lza	lunar zenith angle at the spacecraft	deg	F4	1	$0 \leq x \leq 180$ (-99)
sc_mlat	magnetic latitude at the spacecraft	deg	F4	1	$-90 \leq x \leq 90$ (-99)
sc_mlon	magnetic longitude at the spacecraft	deg	F4	1	$0 \leq x \leq 360$ (-99)
sc_track	track angle at the spacecraft, 360° at the first ascending node within the file.	deg	F4	1	$x \geq 0$ (-99)
table_id	identifier of the scan table controlling the measurement	—	I4	1	$0 \leq x \leq 65535$ (-99)
table_index	current scan table step index	—	I4	1	$1 \leq x \leq 65535$ (-99)
binning_id	binning table identifier, index into array of binning tables [see Table 3]	—	I2	1	$1 \leq x \leq 10$ (-99)
tel_id	telescope azimuth: cal(405°), 1(45°), 2(135°), 3(225°), 4(315°)	deg	I2	1	405, 45, 135, 225, 315 (-99)
int_period	integration period	s	F4	1	$0 \leq x \leq 40.95$ (-99)
elevation	telescope elevation angle, measured from the local horizontal towards the nadir.	deg	F4	1	$10 \leq x \leq 31$ (-99)

Table 6, LOS Record Contents

short name	*Description*	*units*	*type*	*dim.*	*range (missing)*
fw1_position	filter wheel 1 position, 1, 2, …,8 (see section 3.2.2.1 below)	—	I1	1	1, 2, … 8 (-1)
fw2_position	filter wheel 2 position, 1, 2,…,8 (see section 3.2.2.1 below)	—	I1	1	1, 2, … 8 (-1)
fw_config	filter wheel configuration (see section 3.2.2.1 below)	—	I4	1	1, 2, … 15 (-1)
fw_error	filter wheel error (T=error, F=ok)	—	C1	1	"T" | "F" ("?")
fw1_pos_error	filter wheel 1 position error (T=error, F=ok)	—	C1	1	"T" | "F" ("?")
fw2_pos_error	filter wheel 2 position error (T=error, F=ok)	—	C1	1	"T" | "F" ("?")
shut_position	shutter position for the telescope	—	C1	1	"O" | "C" ("?")
los_direction	line of sight geographic azimuth, measured from north towards east	deg	F4	1	$0 \le x \le 360.$ (-99)
view_vector	unit vector along the line of sight expressed in the Earth centered inertial (ECI) coordinate frame		F4	3	$-1 \le x \le 1$ (-99)
flight_dir	flight direction		C1	1	"F" | "B" ("?")
in_saa	True if in the south Atlantic anomaly		C1	1	"T" | "F" ("?")
ascending	True if spacecraft is on the ascending (northbound) leg		C1	1	"T" | "F" ("?")
data_ok	True if data is OK, False if data is contaminated		C1	1	"T" | "F" ("?")
temp_ccd	CCD temperature	°C	F4	1	$-120 \le x \le 60$ (-999)
temp_preamp	CCD pre-amplifier temperature	°C	F4	1	$-120 \le x \le 60$ (-999)
temp_window	CCD window temperature	°C	F4	1	$-120 \le x \le 60$ (-999)
temp_fw_hsg	Filter wheel housing temperature	°C	F4	1	$-50 \le x \le 50$ (-99)
temp_etl_leaf	Etalon mount leaf temperature	°C	F4	1	$-50 \le x \le 50$ (-99)
temp_etl_post	Etalon mount post temperature	°C	F4	1	$-50 \le x \le 50$ (-99)
temp_etl_rod	Etalon mount rod temperature	°C	F4	1	$-50 \le x \le 50$ (-99)

Table 6, LOS Record Contents

short name	*Description*	*units*	*type*	*dim.*	*range (missing)*
temp_base	Profiler base temperature	°C	F4	1	$-50 \le x \le 50$ (-99)
temp_barrel	Telescope mirror / barrel temperature	°C	F4	1	$-50 \le x \le 50$ (-99)
temp_pedestal	Telescope pedestal temperature	°C	F4	1	$-50 \le x \le 50$ (-99)
temp_pwr_sup	Instrument power supply temperature	°C	F4	1	$-50 \le x \le 50$ (-99)
temp_processor	Flight computer temperature	°C	F4	1	$-50 \le x \le 50$ (-99)
temp_1553	Communications (1553) interface temperature	°C	F4	1	$-50 \le x \le 50$ (-99)
p_status	processing status value (See section 3.2.2.2)	—	I4	1	(-99)
cr_contam	indicates suspect channels due to cosmic ray contamination (see section 3.2.2.3 below)	bitmap	I2	5	
sat_flag	indicates suspect channels due to possible signal saturations (see section 3.2.2.3 below)	bitmap	I2	5	
ave_dark	dark count averaged over all spectral bins	counts	F4	1	$\lvert x \rvert \le 4096$ (-9999)
var_dark	variance associated with average dark counts	$(\text{counts})^2$	F4	1	$0 \le x \le 1.6 \cdot 10^7$ $(-9. \cdot 10^8)$
ave_rad	radiation induced background, averaged over all spectral bins	counts	F4	1	$\lvert x \rvert \le 4096$ (-9999)
var_rad	variance associated with average radiation background	$(\text{counts})^2$	F4	1	$0 \le x \le 1.6 \cdot 10^7$ $(-9. \cdot 10^8)$
b	line of sight brightness	R	F4	1	$\lvert x \rvert \le 10^7$ $(-9 \cdot 10^7)$
var_b	estimated line of sight brightness variance	R^2	F4	1	$0 \le x \le 10^{14}$ $(-9 \cdot 10^{14})$
s	line of sight wind speed (positive values are towards telescope)	$m\ s^{-1}$	F4	1	$\lvert x \rvert \le 2000$ (-9999)
var_s	estimated line of sight wind speed variance	$m^2\ s^{-2}$	F4	1	$0 \le x \le 10^6$ $(-9 \cdot 10^6)$
t_doppler	line of sight Doppler width temperature	K	F4	1	$\lvert x \rvert \le 2000$ (-9999)
var_t_doppler	estimated line of sight Doppler width temperature variance	K^2	F4	1	$0 \le x \le 10^6$ $(-9 \cdot 10^6)$
t_rot	line of sight rotational temperature	K	F4	1	$\lvert x \rvert \le 2000$ (-9999)

Table 6, LOS Record Contents					
short name	*Description*	*units*	*type*	*dim.*	*range (missing)*
var_t_rot	estimated line of sight rotational temperature variance	K^2	F4	1	$0 \le x \le 10^6$ $(-9 \cdot 10^6)$
back	line of sight background	R/cm^{-1}	F4	1	$\lvert x \rvert \ x \le 10^7$ $(-9 \cdot 10^7)$
var_back	estimated line of sight background variance	$(R/cm^{-1})^2$	F4	1	$0 \le x \le 10^{14}$ $(-9 \cdot 10^{14})$
earth_rot	Earth rotation correction at each level	ms^{-1}	F4	1	$\lvert x \rvert \le 1000$ (-9999)
var_earth_rot	Earth rotation correction variance	m^2s^{-2}	F4	1	$0 \le x \le 10^6$ $(-9 \cdot 10^6)$
temp_drift	etalon thermal drift correction	ms^{-1}	F4	1	$\lvert x \rvert \le 1000$ (-9999)
var_temp_drift	etalon thermal drift correction variance	m^2s^{-2}	F4	1	$0 \le x \le 10^6$ $(-9 \cdot 10^6)$
chi_square	estimated value of χ^2 for the fit	—	F4	1	$0 \le x \le 10^6$ (-1)
fit_niters	number of iterations for the fit	—	I1	1	$0 \le x \le 30$ (-1)
zero_wind	estimated zero wind (sc_vlos + earth_rot + temp_drift + long term drift + zero_corr)	m/s	F4	1	$0 \le x \le 5000$ (-9999)
zero_corr	correction to the zero_wind from regression analysis	m/s	F4	1	$0 \le x \le 5000$ (-9999)
spec_index	the index in the spectra and spectra variance variables containing the spectral data associated with this line of sight record.	—	I4	1	$x \ge 1$ (-1)

3.2.2.1. *Filter Wheel Configuration, The Fw_Config, Fw1_Position, and Fw2_Position Variables*

The filter wheel configuration variable enumerates the atmospheric features observed. There is a unique filter wheel configuration number specified for each combination of filter wheel positions that provides valid measurement. Table 7, below, lists the emissions and filter wheel positions for each filter wheel configuration number. In the table the columns headed *FW 1* and *FW 2* are the positions of filter wheels 1 and 2 that correspond to the configuration number in the first column.

Table 7: Filter Wheel Configurations					
fw_config	*FW 1*	*FW 2*	*Emission*	*Approx. filter center (nm in air)*	*Approx. filter width (nm)*
1	3	1	O_2 Atm (0-1) [$O_2(^1\Sigma)$(0-1)] P7 pair (11545.2971 and 11543.3255 cm^{-1})	866.12	0.3

Table 7: Filter Wheel Configurations

fw_config	*FW 1*	*FW 2*	*Emission*	*Approx. filter center (nm in air)*	*Approx. filter width (nm)*
			Ar calibration (866.79 nm) Ne calibration (865.55224 nm)		
2	1	1	O_2 Atm (0-1) [$O_2(^1\Sigma)$(0-1)] P11 pair (11531.7989 and 11536.7235 cm^{-1}) Ar calibration (866.79 nm)	867.133	0.3
3	8	1	O_2 Atm (0-0) [$O_2(^1\Sigma)$(0-0)] P9 pair (13093.6407 and 13091.6958 cm^{-1}) Ar calibration line (763.51 nm).	763.68	0.3
4	4	1	O_2 Atm (0-0) [$O_2(^1\Sigma)$(0-0)] P15 pair (13069.9459 and 13068.0662 cm^{-1}).	765.07	0.3
5	5	1	OI(^{1}D) 630 nm red line Ne calibration (630.4789 nm)	630.1	0.5
6	7	1	OI(^{1}S) 557.7 nm green line	557.8	0.5
7	6	8	OII(^{2}D) 732 nm ionized O	732.1	0.5
8	6	7	OI [O (^{3}S $\rightarrow$ ^{3}P)] 844.6 nm.	844.8	0.5
9	6	4	OH (9-4) P1(2) 779.4 nm	779.5	0.5
10	2	1	OH (7-3) P1(3) 891.9 nm Ne calibration (891.95007 nm)	892.1	0.5
11	6	5	Na D doublet Ar calibration (588.85841 nm) Kr calibration (558.18952 nm)	589.4	1.0
12	6	3	wideband O_2 Atm (0-0) P branch Ar calibration (763.51 nm)	764.0	4.0
13	6	2	wideband O_2 Atm (0-0) R branch Kr calibration (760.15 nm)	760.6	2.0
14	6	6	Kr calibration (557.02885 nm)	557.2	0.5
15	7	7	Dark	-	-

3.2.2.2. Processing Status Bitmap, The p_status Variable

The p_status variable is a bitmap that records the errors that occur in processing a TL0 file and gives some sense of the validity of the calculated values, like brightness and line-of-sight wind speeds. The p_status variable is initially set to 0. The bitmap begins at bit 0 in FORTRAN and bits are set using the IBSET function. The table below indicates the meaning assigned to each bit. If the value of the bitwise and of p_status and the bit mask *[iand(p_status,mask)]* is non-zero the specified bit is set indicating that the noted condition occurred. (See TIDI File 055-4328 for further explanation of setting bits 9 through 12.)

Table 8, Processing Status Bitmap (p_status)

bit number	*bit mask*	*Description*
0	0001	set if the remove background routine is removing an averaged background instead of an interpolated value
1	0002	set if convergence does not occur in calculation of line of sight quantities
2	0004	set if fatal error has occurred in FORMOD or AXB – no convergence
3	0008	set if filter wheel configuration is not used for calculation of LOS quantities
4	0016	set if filter wheel configuration is invalid; configuration was not commanded
5	0032	set if spectra is a background, i.e. all shutters were closed during collection
6	0064	set if the removed background is more than twice value of the raw spectra, indicating a possible problem with the remove_background subroutine
7	0128	set if the brightness coming out of fit_spectrum is negative
8	0256	set if the 1st, 2nd, 3rd, or 4th bits are set in the MDC_FLAG for the PVAT data. This indicates that spacecraft position, velocity or roll, pitch and yaw data is not available. No viewing geometry is calculated for data where this is set.
9	0512	telescope 1 data is bad due to contamination by light scattered from telescope 3
10	1024	telescope 1 data is bad due to contamination by light scattered from telescope 4
11	2048	telescope 2 data is bad due to contamination by light scattered from telescope 3
12	4096	telescope 2 data is bad due to contamination by light scattered from telescope 4
13	8192	telescope shutter is is closed. (shut_pos='C') No fit attempted. Not set if FOV is calibration field.
14	16384	LOS wind value exceeds max_wind_value
15	32768	model used in remove_background
16	65536	error in correcting the line-of-sight winds; no zero_correction made
17	131072	filter wheel configuration changed from previous record
18	262144	telescope 1 data is bad due to contamination by light scattered from telescope 2
19	524288	telescope 2 data is bad due to contamination by light scattered from telescope 1
20	1048576	telescope 3 data is bad due to contamination by light scattered from telescope 1
21	2097152	telescope 3 data is bad due to contamination by light scattered from telescope 2
22	4194304	telescope 3 data is bad due to contamination by light scattered from telescope 4
23	8388608	telescope 4 data is bad due to contamination by light scattered from telescope 2
24	16777216	telescope 4 data is bad due to contamination by light scattered from telescope 1

Table 8, Processing Status Bitmap (p_status)		
bit number	*bit mask*	*Description*
25	33554432	telescope 4 data is bad due to contamination by light scattered from telescope 3
26	67108864	previous record had FW error; after FW error, the next measurement is invalid
27	134217728	signal-to-noise ratio is too small for a proper fit of the spectra
28	268435456	not all four telescope scenes present; light contamination is possible

3.2.2.3. The Contaminated Channel Bitmaps, The cr_contam and sat_flag variables

Spectral channels may be contaminated due to energetic particles striking the detector or due to counter saturation. The cr_contam and sat_flag variables indicate that these situations have been identified. The variables are bit maps, that is each bit indicates whether or not the condition occurred on the corresponding detector channel. Since there are more than 16 channels per telescope scene, the bit map extends over multiple words of the variable.

If bit `n` of word `i` is set, then channel `16*i + n +1` is contaminated. The one is added because channel numbers run from 1 to 255 and bits are identified as 0 through 15. For example if bit 5 of word 2 is set, then channel 16*2 + 5 + 1 = 38 is set.

3.2.3. Spectra

The spectra data consist of the spectra for each telescope and the calibration field and their variances.

The spectra are stored in NetCDF variables with names formed by concatenating the string "spec" with the telescope identifier. The spectra variance are stored in NetCDF variables with names formed by concatenating "vspec" with the telescope identifier. The input detector counts are stored in variables with names formed by concatenating "rawspec" with the telescope identifier. The variables, described in Table 9, are two dimension arrays, with one row for each measurement, and one column for each wavelength bin in the spectra. With this dimensioning, each variable has the same number of rows denoted by *NS* in the table, but the number of columns is different for each telescope denoted by *bins* in the table.

The spectra are linked to the data in the LOS records through their array row index. The LOS record for a specific time includes the variable `spec_index`. The value of `spec_index` is the one-based index of the row in the spectra variables, containing the spectra associated with the particular LOS record. Some care is required when selecting a spectra with the `spec_index` variable. The first spectra in the array is denoted by a `spec_index` value of 1. Depending on the language in which the accessing program is written, array subscripts may be zero based (IDL, C) or one based (FORTRAN, BASIC). In the case of C, IDL or any language with zero based array subscripts, the value of spec_index will be one greater than the value of the subscript that indexes the spectra of interest.

Table 9, Spectra and Spectra Variance Variables					
short name	*Description*	*units*	*type*	*dim§.*	*range (missing)*
spec405	observed spectra for the calibration field	R/cm^{-1}	F4	NS, bins	$0 \le x \le 2{\cdot}10^6$ (-99999)
spec045	observed spectra for telescope 1	R/cm^{-1}	F4	NS, bins	$0 \le x \le 2{\cdot}10^6$ (-99999)
spec135	observed spectra for telescope 2	R/cm^{-1}	F4	NS, bins	$0 \le x \le 2{\cdot}10^6$ (-99999)

Table 9, Spectra and Spectra Variance Variables

short name	*Description*	*units*	*type*	*dim*[§].	*range (missing)*
spec225	observed spectra for telescope 3	R/cm^{-1}	F4	NS, bins	$0 \leq x \leq 2 \cdot 10^6$ (-99999)
spec315	observed spectra for telescope 4	R/cm^{-1}	F4	NS, bins	$0 \leq x \leq 2 \cdot 10^6$ (-99999)
vspec405	estimated spectra variance for the calibration field	$(R/cm^{-1})^2$	F4	NS, bins	$0 \leq x \leq 10^{12}$ ($-9 \cdot 10^{12}$)
vspec045	estimated spectra variance for telescope 1	$(R/cm^{-1})^2$	F4	NS, bins	$0 \leq x \leq 10^{12}$ ($-9 \cdot 10^{12}$)
vspec135	estimated spectra variance for telescope 2	$(R/cm^{-1})^2$	F4	NS, bins	$0 \leq x \leq 10^{12}$ ($-9 \cdot 10^{12}$)
vspec225	estimated spectra variance for telescope 3	$(R/cm^{-1})^2$	F4	NS, bins	$0 \leq x \leq 10^{12}$ ($-9 \cdot 10^{12}$)
vspec315	estimated spectra variance for telescope 4	$(R/cm^{-1})^2$	F4	NS, bins	$0 \leq x \leq 10^{12}$ ($-9 \cdot 10^{12}$)
rawspec405	raw detector output for the calibration field	counts	I2	NS, bins	$0 \leq x \leq 4096$ (-9999)
rawspec045	raw detector output for telescope 1	counts	I2	NS, bins	$0 \leq x \leq 4096$ (-9999)
rawspec135	raw detector output for telescope 2	counts	I2	NS, bins	$0 \leq x \leq 4096$ (-9999)
rawspec225	raw detector output for telescope 3	counts	I2	NS, bins	$0 \leq x \leq 4096$ (-9999)
rawspec315	raw detector output for telescope 4	counts	I2	NS, bins	$0 \leq x \leq 4096$ (-9999)

[§] The name of the number of rows (NS) dimension in the netCDF file is `nrecs_size`.
The names of the number of bins (bins) dimension in the netCDF file is `spec`*`nnn`*`_dim`, where *`nnn`* is the scene identifier (Table 5)

3.3. Additional Diagnostic Records

The retrieve program can optionally produce additional diagnostic information. When selected, three additional sets of variables are included in the file containing the background that was applied to the raw detector output and the model spectra reconstructed as part of the retrieval of line of sight parameters. Files that contain these diagnostics are of type ".LOS-TEST".

The background spectra are contained in variables with names formed by concatenating the string "back" with the telescope id. The model spectra are contained in variables with names formed by concatenating the string "sfit" with the telescope ID. The spectra with only the background removed are contained in variables with names formed by concatenating the string "bspec" with the telescope id. The variables, described in Table 10, are two dimension arrays, with one row for each measurement, and one column for each wavelength bin in the spectra. With this dimensioning, each variable has the same number of rows denoted by *NS* in the table, but the number of columns is different for each telescope denoted by *bins* in the table.

The backgrounds (back), model spectra (sfit) and background corrected raw (bspec) spectra are linked to the data in the LOS records through their array row index. The LOS record for a specific time includes the variable `spec_index`. The value of `spec_index` is the one-based index of the row in the variables, containing the background or model spectra associated with the particular LOS record. Some care is required when selecting a spectra with the `spec_index` variable. The first spectra in the array is denoted by a `spec_index` value of 1. Depending on the language in which the accessing program is written, array subscripts may be zero based (IDL, C) or one based (FORTRAN, BASIC). In the case of C, IDL or any language with zero based array subscripts, the value of spec_index will be one greater than the value of the subscript that indexes the spectra of interest.

Table 10, Additional Diagnostic Variables

short name	*Description*	*units*	*type*	*dim*[§].	*range (missing)*
back405	background removed from the calibration field	counts	F4	NS, bins	$0 \le x \le 4096$ (-9999)
back045	background removed from telescope 1	counts	F4	NS, bins	$0 \le x \le 4096$ (-9999)
back135	background removed from telescope 2	counts	F4	NS, bins	$0 \le x \le 4096$ (-9999)
back225	background removed from telescope 3	counts	F4	NS, bins	$0 \le x \le 4096$ (-9999)
back315	background removed from telescope 4	counts	F4	NS, bins	$0 \le x \le 4096$ (-9999)
sfit405	model spectra for the calibration field	R/cm^{-1}	F4	NS, bins	$0 \le x \le 2\cdot10^6$ (-99999)
sfit045	model spectra for telescope 1	R/cm^{-1}	F4	NS, bins	$0 \le x \le 2\cdot10^6$ (-99999)
sfit135	model spectra for telescope 2	R/cm^{-1}	F4	NS, bins	$0 \le x \le 2\cdot10^6$ (-99999)
sfit225	model spectra for telescope 3	R/cm^{-1}	F4	NS, bins	$0 \le x \le 2\cdot10^6$ (-99999)
sfit315	model spectra for telescope 4	R/cm^{-1}	F4	NS, bins	$0 \le x \le 2\cdot10^6$ (-99999)
bspec405	calibration field spectra after background is removed and converted to geophysical units	R/cm^{-1}	F4	NS, bins	$0 \le x \le 2\cdot10^6$ (-99999)
bspec045	telescope 1 spectra after the background is removed and converted to geophysical units	R/cm^{-1}	F4	NS, bins	$0 \le x \le 2\cdot10^6$ (-99999)
bspec135	telescope 2 spectra after the background is removed and converted to geophysical units	R/cm^{-1}	F4	NS, bins	$0 \le x \le 2\cdot10^6$ (-99999)
bspec225	telescope 3 spectra after the background is removed and converted to geophysical units	R/cm^{-1}	F4	NS, bins	$0 \le x \le 2\cdot10^6$ (-99999)
bspec315	telescope 4 spectra after the background is removed and converted to geophysical units	R/cm^{-1}	F4	NS, bins	$0 \le x \le 2\cdot10^6$ (-99999)

[§] The name of the number of rows (NS) dimension in the netCDF file is `nrecs_size.`
The names of the number of bins (bins) dimension in the netCDF file is `spec`*`nnn`*`_dim`, where *`nnn`* is the scene identifier (Table 5)

4. Naming Convention

File names consist of a file description string and a file type string separated by the period "." character. TIDI line of sight files have the file type ".LOS" and will be named according to the convention specified in reference 4. The diagnostic files have the file type ".LOS-TEST"