

# Guide to the distributable IDL version of the SLIMED application

Hugh H. Kieffer File=/home/hkieffer/lunar/SLICS/Guide.tex

April 13, 2023

## Contents

<b>1</b>	<b>Overview</b>	<b>1</b>
1.1	Background . . . . .	1
1.1.1	Related documents . . . . .	1
1.2	Introduction . . . . .	2
1.3	Versions of the SLIMED application . . . . .	2
<b>2</b>	<b>Architecture</b>	<b>2</b>
2.1	Utility routines . . . . .	3
2.2	Worker routines . . . . .	3
2.3	Time and formats . . . . .	3
2.4	Dimensioning to minimize code . . . . .	3
2.5	Oversampling . . . . .	4
2.6	Viewer location . . . . .	4

## 1 Overview

### 1.1 Background

The SLIMED model of lunar spectral irradiance was developed in a proprietary language, IDL, as was the prior model, ROLO. To make the model publically available, it must be written in a common, non-proprietary language. The original version of SLIMED had many poorly-explained options and customised file formats and required direct calls to the FORTRAN version of the JPL planetary ephemeris. A streamlined version with the same file format and ephemeris access was released to a few colleagues near the end of 2022. The current version, SLIMED.2, uses a modular architecture, common file formats, and a widely-available ephemeris package.

#### 1.1.1 Related documents

Algo.pdf: 'Calibration with a lunar model: algorithm description', based on the SLIMED model. Written before and during the generation of SLIMED.2, with some updating.

Framework.pdf: Copy of Tom Stone document 'Proposed Framework for a New GSICS Lunar Model Implementation', version of 2023 Feb 22

'High Level Description of the GIRO Application and Definition of the Input/Output Formats' EUMETSAT document EUM/TSS/TEN/14/753739, 2015 Feb 24

## 1.2 Introduction

The SLIM system includes developing a SLIMED model from many observations and computing a SLIMED model for a set of observation and using this to generate calibration ratios of: observed / modeled irradiance. This document describes the SLIMED application, meant to be generally runnable in IDL and to serve as a basis for conversion into a common language. All files are NetCDF, with generous descriptions.

The JPL SPICE system is used for most geometry work and time conversion. However, only two routines, SLIM2PG and its calls to SPICEMOON, uses any SPICE routines other than time conversion.

Every file includes addition to a history log which contains as a minimum the process name and version, the run time, and a point of contact.

There is some complexity due to preserving generality so that much of the software could support new model development as well as model application.

Some of this complexity could be omitted. E.g.

- The use of effective wavelengths (which are required for model development). This would require generating the full set of 2115 model irradiances for every observation, but not much change of code. Estimated increase in execution time by about a factor of 100. This would bring the system closer to the Framework set out by Tom Stone.
- The ability to handle apparent moon size as an over-sampling term. Used by OLI and SeaWiFS.
- The ability to handle a surface observatory location, requiring only observation time.

The SLIMED.2 code set includes everything needed to do a lunar calibration. It would be possible to produce a smaller code set that only produced the SLIMED model for a given time, viewer location, and any set of wavelengths. Basically this would involve using the SLIM2PG algorithm with input arguments for the instrument data rather than reading instrument files, and merging that with the SLIM2MC algorithm.

## 1.3 Versions of the SLIMED application

SLIMED.0: Original development, in use when the SPIE article published. Continuous revisions

SLIMED.1 First distribution, 2022 Dec 21. Used .bin files and direct call to the JPL ephemeris

SLIMED.2 Second distribution, 2023 Apr ?? . Revised architecture, only NetCDF files, SPICE routines for geometry.

## 2 Architecture

Two routines, SLIMFAME and SLIMSATT, are called often and contain firm-code string arrays that are largely instrument specific and meant to be modified by each institution. These two routine could be restructured to read files for institution-specific information.

The reference lunar and solar spectra, the TSI variation and its spectral sensitivity are package in one file, *Slim-RefSpec.nc*. Similarly, the specification of the SLIMED model is in one file, *22Apr16T1827\_mdl.nc*. These names are firm-coded in SLIMFAME.

SLIMNTOP will successively call all routines needed to ingest files for one instrument into the SLIM system and execute all stages to generate the intermediate files and the SLIMED model and produce calibration ratios. These major routines are listed below; the first four are “Stage One”, mostly reformatting. The last 3 are “Stage Two” and do the real work. ‘ACRO’ means the instrument acronym.

**GITOS** A skeleton routine that will need to be edited for each instrument, or to make a general version that reads sets of GIRO files. It uses several SLIM2xx routines to write the files so as to ensure proper format and content.

**SLIM2WT** Concatenates the relative spectral response of bands in team order, writes a file that included the band names and nominal wavelength.  $\Rightarrow$  *ACRO\_wt.nc*

**SLIM2TV** Reformats observation time and location into standard form. Can accomodate a primary (normally UTC calendar string) and secondary form of time. Can accomodate a fixed ground location. Can accomodate oversampling factor or apparest along-scan size of the Moon. Ensures at least 2 dates.  $\Rightarrow$  *ACRO.tv.nc* overwrite

**SLIM2IR** Reformats observed irradiances into standard form. Ensures at least 2 dates.  $\Rightarrow$  *ACRO.ir.nc* overwrite

**SLIM2EW** Processes *ACRO.wt.nc* files. Interpolates onto the UPRS system, and computes the effective wavelength for the Moon, the mean in-band lunar irradiance for the reference Moon and Sun, and several other band properties. It calls DINTERP to do the resampling.  $\Rightarrow$  *ACRO.rw.nc* and  $\Rightarrow$  *ACRO.ew.nc*

**SLIM2PG** Computes the photometric angles and distance factor. Can convert apparent along-scan Moon size to an oversampling factor. If calls SPICEMOON to do the geometric work. Can handle viewer in space or at a fixed ground location. Can convert along-scan Moon size into oversample factor.  $\Rightarrow$  *ACRO.pg.nc*

**SLIM2MC** Generates the lunar model and the calibration ratio. Calls SID2BIJ to convert basis functions and coefficients into model values.

## 2.1 Utility routines

**SLIMFAME** Handles the parts of file names. It intentionally has extra items to allow for multiple similar instruments and alternate processing versions; these default to null.

**SLIMSATT** Handles the standard attributes, including any and all formal statements.

**SLIMNOW** produce the current time in all forms used by SLIM, including ISO-8601

**READ\_NC** Read a NetCDF file and return a set of attributes by name (or the first N, or all) and a set of variables by name.

**FILEUNIQ** Handle to generation of output file names, with several options if the proposed file already exists. It is currently not used in SLIM2TV or SLIM2IR.

## 2.2 Worker routines

**DINTERP** Rigorous resampling of spectra without smoothing.

**SID2BIJ** Conversion of angle and wave basis functions, symbolic terms, and coefficients into model values. Intricate and perhaps obscure.

**SPICEMOON** Converts time and observer (viewer) location into photometric angles and distance factor. Also produces five less-commonly used angles

## 2.3 Time and formats

In SLIMED, observation time is stored in 3 formats.

Early .bin files: 'MJD' is days from 2000 Jan 01 noon UTC,

Input, .tv file, UTCc as string, precision unlimited

Geometry, .pg file: ET seconds in double precision, 1.1E-16 proportion, or 0.1 microsec in 50 years

Model, .cal file: ET in days, single precision, 6.e-08 proportion. Accuracy linear with time from 2000 Jan 01, grows to 1.6 minutes by 2050.

## 2.4 Dimensioning to minimize code

For instruments like OLI, which do raster scans to cover multiple Focal Plane Modules (FPM's), the source irradiance (and perhaps location) data may be dimensioned (FPM, date, band). To avoid processing complications, these are reformed to (FPM\*date,band) and a note added to the variable description.

In the rare case that an instrument has a single date (such as the Cramer NIST observation) it is copied with a time one second later in SLIM2TV and SLIM2IR to avoid latter complications.

## 2.5 Oversampling

The SLIM system allows adjustment of irradiance for over-sampling and the status is tracked by the attribute 'oversamp\_stat' listed in parenthesis below. An over-sampling factor can be provided by a team, either as simply a record ('team') or to be applied in SLIM processing ('calib'). Also, for historic reasons, a team may instead provide a measure of the apparent along-scan angular diameter of the Moon ('Yang'), which will be converted to an oversampling factor ('calib') and applied.

## 2.6 Viewer location

For a ground-fixed observatory, a team need supply only the fixed observatory location and time but optionally may also or only supply the ECI positions. If both are supplied, the ground location takes precedence. All other instruments must supply ECI positions.