PV\_LIB changelog since version 1.0

2012-07-16 to 2012-07-18

1. Added the folder “\Required Data” to hold required data sets
2. Added pvl\_clearsky\_ineichen (name change by JSS) (Created html help file)
3. Added Linke turbidity data sets for use in pvl\_clearksy\_ineichen to the \Required Data folder. LinkeTurbidity.mat is a read-only file.
4. Fixed a typo in the “help” information for pvl\_dirint
   1. original stated that “inputs must be a vector of length <2”, which was changed to “of length >2”.
   2. changed word “inrradiance” to “irradiance” in the description.
5. Added pvl\_clearsky\_haurwitz (name change by JSS) (Created html help file)
6. Changed the “help” information for pvl\_grounddiffuse to be more descriptive/helpful/correct

2012-08-15

1. Changed the “help” information for pvl\_sapm to reduce ambiguity.
   1. Changed word “Strucutre” to “Structure” in explanation of outputs.
   2. Changed word “standard cell temperature” to “reference cell temperature” in the description

2012-09-07

1. Added pvl\_physicaliam (Created html help file)
2. Added pvl\_fiveparam\_desoto (removed on 2012-09-21)
3. Added wapr\_vec
4. Added pvl\_fminbnd\_vec.p, which is a vectorized version of MATLAB’s fminbnd function. Operates much faster than fminbnd. Obscured the source code and created a “.p” file in order to comply with Mathworks’ License Agreement, particularly the Deployment Addendum.
5. Added pvl\_fminbnd\_vec.m which is merely a “help” file for pvl\_fminbnd\_vec.p

2012-09-10

1. Added functionality to pvl\_spa. The function pvl\_spa can now correctly process times which occurred prior to the advent of the Gregorian calendar (i.e. prior to October 15, 1582). (Does this require an update to the help files?)
   1. No changes to help files required for this change
2. Added pvl\_ashraeiam (Created html help file)

2012-09-19

1. Removed refraction correction from pvl\_spa estimate of solar elevation angle when “true” solar elevation angle is less than -1\*(atmospheric refraction at horizon + sun radius), which is approximately -0.83337 degrees.’
   1. The “help” documentation has not changed after this was implemented, I (Dan) don’t think that we need to update the help documentation.

2012-09-21

1. Modified wapr\_vec to accept and process 2D arrays (rather than only scalars and vectors).
2. Added pvl\_singlediode
3. Added pvl\_calcparams\_desoto
4. Removed pvl\_fiveparam\_desoto. This function has been replaced by pvl\_singlediode and pvl\_calcparams\_desoto.

2012-09-24

1. Corrected file pvl\_singleaxis.
   1. The function call within the .m file used to be named “pvl\_singleaxis\_dev”, changed to “pvl\_singleaxis”.
   2. Changed spacing on the Output portion of the help file to reflect similar spacing in other scripts.
   3. Added PVL\_SPA to the “See Also” section.
   4. Changed output name from “SurfEl” to “SurfTilt” to more accurately describe the output
   5. I also noticed that the help documentation has changed slightly from the V1\_0 version. In the new .m file, the additional outputs “SurfEl” and “SurfAz” are listed as outputs.

2012-11-26

1. Bugs found by Rob Andrews of Queen’s University in pvl\_perez
   1. Angle of incidence determination incorrect. Corrected angle of incidence function from   
      cosd(SurfTilt).\*cosd(SunZen) + sind(SurfTilt) .\* sind(SunZen) .\* cosd(SunAz+180-SurfAz)  
      to   
      cosd(SurfTilt).\*cosd(SunZen) + sind(SurfTilt) .\* sind(SunZen) .\* cosd(SunAz-SurfAz)
   2. Corrected the final calculation of sky diffuse content from   
      DHI(ebinfilter).\* 0.5.\* (1-F1(ebinfilter)) .\* (1+cosd(SurfTilt(ebinfilter))) + F1(ebinfilter) .\* A(ebinfilter) ./ B(ebinfilter) + F2(ebinfilter).\* sind(SurfTilt(ebinfilter))  
      to   
      DHI(ebinfilter).\* (0.5.\* (1-F1(ebinfilter)) .\* (1+cosd(SurfTilt(ebinfilter))) + F1(ebinfilter) .\* A(ebinfilter) ./ B(ebinfilter) + F2(ebinfilter).\* sind(SurfTilt(ebinfilter)))
2. Corrected a bug in pvl\_perez where scalar SurfTilt and SurfAz values were not processed correctly. Added a check to ensure that any scalar input vectors are made into constant column vectors of the same length as the largest input vector.
3. Corrected pvl\_haydavies1980 angle of incidence function as described in pvl\_perez fix notes.
4. Corrected pvl\_klucher1979 angle of incidence function as described in pvl\_perez fix notes.
5. Corrected pvl\_reindl1990 angle of incidence function as described in pvl\_perez fix notes.

2012-12-11

1. Added new .mat files which mimic the SAM library files
   1. CECModuleDatabaseSAM2012.11.30.mat
   2. SandiaInverterDatabaseSAM2012.11.30.mat
2. Added SAM library file reader functions: pvl\_SAMLibraryReader\_CECModules.m and pvl\_SAMLibraryReader\_SNLInverters.m for reading SAM library files and generating a list of names and a vector of structures with the library information.
3. Added a warning to pvl\_snlinverterdb.m stating that the function would be removed in a future version of PV\_LIB and directing users to use the new .mat files or the SAM library readers.

2012-12-12

1. Added a “thank you” to the SAM team in each of the SAM library reader functions (in the notes)
2. Added information in the “help” file of pvl\_snlinverter to guide users to the .mat file of inverter parameters and the SAM inverter parameter reader.
3. Added information in the”help” file of pvl\_calcparams\_desoto to guide users to the .mat file of CEC database parameters and the SAM CEC module parameter reader

2013-01-08

1. PV\_LIB Version 1.1 Released

PV\_LIB changelog since version 1.1

2013-01-11

1. Fixed the help text for pvl\_alt2pres. A “rogue” end of line was present in the help file, ending the “help” text prior to listing the inputs.

2013-01-14

1. Corrected pvl\_clearsky\_ineichen to correctly reference pvl\_clearsky\_haurwitz and Vice Versa
2. Corrected pvlib\_functions\_by\_cat.m. Changed “ephermis” to “ephemeris”
3. Corrected pvlib\_functions\_by\_cat.m. Changed “pvl\_perez\_help” to “pvl\_perez”
4. Corrected pvl\_klucher1979. Statement GHI(GHI<DHI) = DHI did not work for vectors, changed to GHI(GHI<DHI) = DHI(GHI<DHI)

2013-01-17

1. Corrected pvl\_calcparams\_desoto.m.
   1. Removed line M = max(M, 0); which set values of M which were less than 0 to 0
   2. Removed line S(S==0) = 1E-10;
   3. Added line IL(isnan(M) | M<0 | S <=0) = 0; This sets IL to 0 when
      1. Irradiance is <0 or
      2. Airmass modifier is <0 (most likely due to evaluating the polynomial at very high airmass or
      3. Airmass modifier is NaN, which is returned by pvl\_relativeairmass for sun zenith angles > 90 degrees
   4. Added line I0(IL==0) = 0; According the circuit diagram, IL is the only source, and therefore, there can be no reverse saturation current (I0) when IL is 0
   5. Added line Rsh(S <= 0) = inf; This is due to the fact that Rsh is determined by dividing by S, negative values would give a negative Rsh, and at S=0 Rsh is undefined
2. Modified pvl\_singlediode.m
   1. Pre-allocate memory to Imax, negPmp, Vmax, Ix, Ixx, Voc, and Isc. This is necessary in order to use the filter (see below)
   2. Added a filter u = IL > 0; Thus we only compute IV points and IV curves when there is a photocurrent (IL)
   3. Changed the Isc and Voc generation lines to only generate Isc and Voc under conditions which satisfy filter u.
   4. Changed Imax and negPmp finding line to only find Imax and negPmp when conditions satisfy filter u
   5. Changed Vmax, Ixx, and Ix generation lines to only generate the values under conditions which satisfy filter u
   6. Pre-allocate memory for Result.I and Result.V (necessary to implement filter u).
   7. Changed Result.I finding line in order to only find I-V curve currents under conditions which satisfy filter u
   8. Added line Result.I(:,end) = 0; in order to ensure that the current at Voc is exactly 0 (prevents numerical error which may result in a negative current at Voc).
3. Corrected errors in wapr\_vec.m. From line 134 through line 154 (inclusive), the Lambert W function is evaluated piecewise over the domain (-exp(-1), inf) using four approximations. The domain is partitioned into four disjoint sets and each approximation is applied to one (and only one) set. Filters were implemented incorrectly which allowed later approximations to overwrite values obtained from early approximations.

2013-02-08

1. Corrected pvl\_calcparams\_desoto.m documentation. The documentation used to specify that alpha\_isc should be in units of 1/C, it now specifies that alpha\_isc should be in units of A/C or A/K. Documentation was changed rather than code due to the fact that the SAM CEC module database lists alpha\_isc in units of A/C.
   1. Thanks to Martin Herrerias Azcue for the bug find.

2013-05-21

1. Corrected pvl\_calcparams\_desoto.m. Prior input checking for EgRef was p.addRequired('EgRef', @(x) (isnumeric(x) & isvector(x) & x>0)); this has been changed to p.addRequired('EgRef', @(x) (isnumeric(x) & isvector(x) & all(x>0))); in order to ensure that all EgRef values are positive.
   1. Thanks to John McKeen at DOW Solar Solutions for the bug find

2013-09-05

1. Corrected pvl\_clearsky\_ineichen to use system-dependent file separators when using the default Linke Turbidity index. Prior code was: load('Required Data\LinkeTurbidities.mat');  
   this has been changed to load(['Required Data' filesep 'LinkeTurbidities.mat']); in order to allow for system-specific file separators.
   1. Thanks to Mark Campanelli at NREL for finding this bug

2013-10-15

1. Modified pvl\_singlediode to not require pvl\_fminbnd in order to find the maximum power point. Prior to this change, maximum power point was found by finding the maximum value of the power-current curve using a modified version of MATLAB’s fminbnd function. pvl\_singlediode now finds where dP/dV as a function of current is equal to 0. Uses bisection techniques.
   1. New subfunctions “calc\_phi\_exact”, “calc\_Imp\_bisect”, “g”, and “calc\_Pmp\_bisect” were added.
   2. Prior code was left in the function and commented out to allow for reversion later if necessary.

2013-11-27

1. Modified pvl\_getaoi to avoid complex values. Changed the line:   
   AOI = acosd(cosd(SunZen).\*cosd(SurfTilt)+sind(SurfTilt).\*sind(SunZen).\*cosd(SunAz-SurfAz));   
   to the following:  
   AOI = acosd(max(min(cosd(SunZen).\*cosd(SurfTilt)+sind(SurfTilt).\*sind(SunZen).\*cosd(SunAz-SurfAz), 1),-1));
   1. Roundoff errors previously could cause the argument of the arcos function to be greater than 1 or less than -1 (resulting in a complex output). The min and max functions prevent such an occurrence.

2014-09-10

1. Modified pvl\_getaoi to avoid complex values. Changed the line:   
   AOI = acosd(max(min(cosd(SunZen).\*cosd(SurfTilt)+sind(SurfTilt).\*sind(SunZen).\*cosd(SunAz-SurfAz), 1),-1));  
   to the following:  
   temp = cosd(SunZen).\*cosd(SurfTilt)+sind(SurfTilt).\*sind(SunZen).\*cosd(SunAz-SurfAz);   
   temp(temp>1) = 1; temp(temp<-1) = -1;   
   AOI = acosd(temp);
   1. Roundoff errors previously could cause the argument of the arcos function to be greater than 1 or less than -1 (resulting in a complex output). The min and max functions did not prevent all occurrences.

2014-09-10

1. Added pvl\_erbs
2. Added pvl\_louche
3. Added pvl\_orgill\_hollands
4. Added pvl\_reindl\_1
5. Added pvl\_reindl\_2
6. Added pvl\_adrinverter

PV\_LIB changelog since version 1.2

2015-05-21

1. Corrected the pvl\_erbs file. Erbs’ paper specifies that for 0.22< Kt <=0.8, the DF function is governed by the function 0.9511 - 0.1604\*Kt + 4.388\*Kt2 – 16.638\*Kt3 + 12.336\*Kt4. This fix changed the second order coefficient from 4.3888 to 4.388.

2015-10-26

1. Added code for single diode model parameter estimation (De soto and PVsyst). Includes the following functions: pvl\_desoto\_parameter\_estimation, pvl\_PVsyst\_parameter\_estimation, pvl\_est\_single\_diode\_param, pvl\_Schumaker\_QSpline, pvl\_rectify\_IV\_curve, pvl\_converge, calc\_theta\_phi\_exact, update\_Io\_known\_n, update\_Rsh\_fixed\_pt.
2. Edited pvl\_calcparams\_desoto so that the function assumes the input is effective irradiance (rather than absorbed irradiance, i.e., broadband irradiance reaching the module’s cells). pvl\_calcparams\_desoto no longer calculates and applies the spectral mismatch modifier. Edited pvl\_calcparams\_desoto\_help
3. Replaced wapr\_vec with pvl\_lambertw. Wapr\_vec is now obsolete.
4. Included input data for two demonstrations of single diode model parameter estimation.

2015-11-04

1. Added code to fetch and read Integrated Surface Database (ISD) data from [ftp.noaa.gov](ftp://ftp.noaa.gov): pvl\_getISDdata, pvl\_readISH. These functions use the Matlab function readtable which is available in Matlab 2015a and later.

2015-11-18

1. Added code for the Huld PV module model.

2015-11-20

1. Added code pvl\_calcparams\_CEC for the CEC 6-parameter performance model.

2015-12-03

1. Edited input verification for pvl\_haydavies1980 and pvl\_perez to permit NaN in input vectors

2015-12-14

1. Added functions pvl\_FSspeccorr and pvl\_calcPwat to implement FirstSolar’s spectral mismatch modifier model

2015-12-17

1. Removed pvl\_snlinverterdb (made obsolete by pvl\_SAMLibraryReader\_SNLInverters.m and SandiaInverterDatabaseSAM2014.1.14.mat)
2. Changed pvl\_erbs, pvl\_louche, pvl\_orgill\_hollands, pvl\_reindl\_1, and pvl\_reindl\_2 to output DNI, DHI and Kt, and to clarify each model’s description.
3. Corrected description of pvl\_kingdiffuse to clarify that the King diffuse model estimates total plane-of-array diffuse (sky diffuse and ground reflected irradiance).

2015-12-22

1. Added CEC module library and inverter library from SAM2015.6.30 in .csv format and in .mat format, along with scripts to read the .csv files and write the .mat files.

Fixes for version 1.31

2016-1-13

1. Put files est\_single\_diode\_param, Schumaker\_QSpline, calc\_theta\_phi\_exact, update\_Io\_known\_n, update\_Rsh\_fixed\_pt back into the toolbox. These files had been private functions in both pvl\_desoto\_parameter\_estimation and pvl\_PVsyst\_parameter\_estimation and were pulled out as separate functions, but were left out of the version 1.3 distribution.
2. Edited est\_single\_diode\_param to replace calls to zscore and princomp (Statistics toolbox functions) with basic Matlab code.

Changes for version 1.32

1. Revised coefficients in pvl\_FSspeccorr to new values provided by FirstSolar.
2. Added pvl\_robustfit.m to provide an option for pvl\_desoto\_parameter\_estimation and pvl\_PVsyst\_parameter\_estimation that doesn’t rely on the Matlab Statistics Toolbox. Added py\_rlm.py which is the Python code used if the Statistics Toolbox is not present.
3. Added pvl\_Huld\_parameter\_estimation

4. Corrected pvl\_snlinverter to change ACPower(ACPower<Ps0)= -1.\*abs(Pnt); to ACPower(DCPower<Ps0)= -1.\*abs(Pnt

Changes for version 1.4

2018-8-16

1. Bug fix in pvl\_readTMY3 to correctly return header information (thanks shirubana)
2. API change for IAM functions. Old function names had the pattern pvl\_<modelname>iam.m. New function names have the pattern pvl\_iam\_<modelname>.m. The new naming convention mimics names for pvl\_clearsky\_<modelname> functions.
3. Added function pvl\_iam\_martinruiz\_components to return fractions of irradiance loss for beam, isotropic sky diffuse, and ground reflection diffuse due to surface reflections.
4. Extended pvl\_perez to also return isotropic, circumsolar and horizon components of sky diffuse irradiance.
5. API change to rename est\_single\_diode\_param to pvl\_est\_single\_diode\_param.
6. Added functions to implement IV curve translation for methods 1 and 2 in IEC60891: pvl\_translate\_IV\_curve\_IEC60891\_1 and pvl\_translate\_IV\_curve\_IEC60891\_2. Parameters for the curve translation can be calculated using pvl\_est\_Rs\_IEC60891\_1 and pvl\_est\_kappa\_IEC60891\_1, and pvl\_est\_Rs\_IEC60891\_2 and pvl\_est\_kappa\_IEC60891\_2, respectively.
7. Added functions to estimate series resistance from IV curves for methods published by various authors: pvl\_est\_Rs\_Swanson, pvl\_est\_Rs\_Bowden, pvl\_est\_Rs\_sunsVoc, pvl\_est\_Rs\_Pysch.
8. Added functions to model rear-surface irradiance for bifacial PV modules, contributed by Xingshu Sun of Purdue University: pvl\_Purdue\_albedo\_model, pvl\_Purdue\_bifacial\_irradiance, example\_pvl\_Purdue\_albedo\_model, example\_pvl\_Purdue\_bifacial\_irradiance.