



Designation: G173 – 23

Standard Tables for Reference Solar Spectral Irradiances: Direct Normal and Hemispherical on 37° Tilted Surface¹

This standard is issued under the fixed designation G173; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

A wide variety of solar spectral energy distributions occur in the natural environment and are simulated by artificial sources during product, material, or component testing. To compare the relative optical performance of spectrally sensitive products a reference standard solar spectral distribution is required. These tables replace ASTM standard G159, which has been withdrawn. The solar spectral energy distributions presented in this standard are not intended as a benchmark for ultraviolet radiation in weathering exposure testing of materials, which is addressed, at least in part, by ASTM standard **G177**. The spectra are based on version 2.9.9 of the Simple Model of the Atmospheric Radiative Transfer of Sunshine (SMARTS) atmospheric transmission code (**1,2**).² SMARTS uses empirical parameterizations of version 4.0 of the Air Force Geophysical Laboratory (AFGL) Moderate Resolution Transmission model, MODTRAN (**3,4**) for some gaseous absorption processes, and recent spectroscopic data for others. An extraterrestrial spectrum differing slightly from the extraterrestrial spectrum in Tables **E490** is used to calculate the resultant spectra (**5**). The hemispherical tilted spectrum is similar to the hemispherical spectrum in use since 1987, but differs from it because: (1) the wavelength range for the current spectrum has been extended deeper into the ultraviolet; (2) uniform wavelength intervals are now used; (3) more representative atmospheric conditions are represented; and (4) SMARTS Version 2.9.9 has been used as the generating model. For the same reasons, and particularly the adoption of a remarkably less turbid atmosphere than before, significant differences exist in the reference direct normal spectrum compared to previous versions of this standard. The input parameters used in conjunction with SMARTS for the selected atmospheric conditions are tabulated.

1. Scope

1.1 These tables contain terrestrial solar spectral irradiance distributions for use in terrestrial applications that require a standard reference spectral irradiance for hemispherical solar irradiance (consisting of both direct and diffuse components) incident on a sun-facing, 37° tilted surface or the direct normal spectral irradiance. The data contained in these tables reflect reference spectra with uniform wavelength interval (0.5 nanometer (nm) below 400 nm, 1 nm between 400 nm and 1700

nm, an intermediate wavelength at 1702 nm, and 5 nm intervals from 1705 nm to 4000 nm). The data tables represent reasonable cloudless atmospheric conditions favorable for photovoltaic (PV) energy production, as well as weathering and durability exposure applications.

1.2 The 37° slope of the sun-facing tilted surface was chosen to represent the average latitude of the 48 contiguous United States.

1.3 The air mass and atmospheric extinction parameters are chosen to provide (1) historical continuity with respect to previous standard spectra, (2) reasonable cloudless atmospheric conditions favorable for photovoltaic (PV) energy production or weathering and durability exposure, based upon modern broadband solar radiation data, atmospheric profiles, and improved knowledge of aerosol optical depth profiles. In nature, an extremely large range of atmospheric conditions can

¹ These tables are under the jurisdiction of ASTM Committee **G03** on Weathering and Durability and are the direct responsibility of Subcommittee **G03.09** on Radiometry.

Current edition approved March 1, 2023. Published August 2023. Originally approved in 2003. Last previous edition approved in 2020 as G173 – 03(2020). DOI: 10.1520/G0173-23.

² The boldface numbers in parentheses refer to the list of references at the end of this standard.

be encountered even under cloudless skies. Considerable departure from the reference spectra may be observed depending on time of day, geographical location, and changing atmospheric conditions.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:³

E490 Standard Solar Constant and Zero Air Mass Solar Spectral Irradiance Tables

E772 Terminology of Solar Energy Conversion

G159 Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test (Withdrawn 2005)⁴

G177 Tables for Reference Solar Ultraviolet Spectral Distributions: Hemispherical on 37° Tilted Surface

G214 Test Method for Integration of Digital Spectral Data for Weathering and Durability Applications

3. Terminology

3.1 *Definitions*—Definitions of most terms used in this specification may be found in Terminology **E772**.

3.2 *Definitions*:The following definition differs from that in Terminology **E772**, representing information current as of this revision.

3.2.1 *solar constant, n* —the total solar irradiance at normal incidence on a surface in free space at the earth’s mean distance from the sun. (1 astronomical unit, or AU = 1.496×10^{11} m).

3.2.1.1 *Discussion*—Existing accepted values are $1367.0 \text{ W}\cdot\text{m}^{-2}$ (World Meteorological Organization, WMO), and $1361.0 \text{ W}\cdot\text{m}^{-2}$ (International Astronomical Union, IAU), and are still subject to change. Due to the eccentricity of the earth’s orbit, the actual extraterrestrial solar irradiance varies by $\pm 3.4\%$ about the solar constant as the earth-sun distance varies through the year. Throughout this standard the solar constant is defined as $1361.1 \text{ W}\cdot\text{m}^{-2}$, according to a recent evaluation based on a 42-year satellite-based observational record (**6**).

3.3 Definitions of Terms Specific to This Standard:

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard’s Document Summary page on the ASTM website.

⁴ The last approved version of this historical standard is referenced on www.astm.org.

3.3.1 *aerosol optical depth (AOD)*—the wavelength-dependent total extinction (scattering and absorption) by aerosols in the atmosphere. This optical depth (also called “optical thickness”) is defined here at 500 nm.

3.3.1.1 *Discussion*—See **Appendix X1**.

3.3.2 *air mass zero (AM0)*—describes solar radiation quantities outside the Earth’s atmosphere at the mean Earth-Sun distance (1 Astronomical Unit). See Tables **E490**. The AM0 spectrum used here is based on recent satellite-based measurements (**5**).

3.3.3 *integrated irradiance $E_{\lambda_1-\lambda_2}$* —spectral irradiance integrated over a specific wavelength interval from λ_1 to λ_2 , measured in $\text{W}\cdot\text{m}^{-2}$; mathematically (see “spectral integration” in Test Method **G214**):

$$E_{\lambda_1-\lambda_2} = \int_{\lambda_1}^{\lambda_2} E_{\lambda} d\lambda \quad (1)$$

3.3.4 *solar irradiance, hemispherical E_H* —on a given plane, the solar radiant flux received from within the 2π steradian field of view of a tilted plane from the portion of the sky dome and the foreground included in the plane’s field of view, including both diffuse and direct solar radiation.

3.3.4.1 *Discussion*—For the special condition of a horizontal plane the hemispherical solar irradiance is properly termed global solar irradiance (or global horizontal irradiance), E_G . Additionally, global tilted is often used to indicate hemispherical irradiance for a tilted plane. In case of a sun-tracking receiver, this hemispherical irradiance is commonly called global normal irradiance.

3.3.5 *solar irradiance, spectral E_{λ}* —solar irradiance E per unit wavelength interval at a given wavelength λ (unit: Watts per square meter per nanometer, $\text{W}\cdot\text{m}^{-2}\cdot\text{nm}^{-1}$):

$$E_{\lambda} = \frac{dE}{d\lambda} \quad (2)$$

3.3.6 *spectral interval*—the distance in wavelength units between adjacent spectral irradiance data points.

3.3.7 *spectral passband*—the effective wavelength interval within which spectral irradiance is allowed to pass, as through a filter or monochromator. The convolution integral of the spectral passband (normalized to unity at maximum) and the incident spectral irradiance produces the effective transmitted irradiance.

3.3.7.1 *Discussion*—Spectral passband may also be referred to as the spectral bandwidth of a filter or device. Passbands are usually specified as the interval between wavelengths at which one half of the maximum transmission of the filter or device occurs, or as full-width at half-maximum, FWHM.

3.3.8 *spectral resolution*—the minimum wavelength difference between two wavelengths that can be identified unambiguously.

3.3.8.1 *Discussion*—In the context of this standard, the spectral resolution is simply the interval, $\Delta\lambda$, between spectral data points, or the *spectral interval*.

3.3.9 *total ozone*—the depth of a column of pure ozone equivalent to the total of the ozone amount in a vertical column from the ground to the top of the atmosphere (unit: atmosphere-cm or atm-cm).



3.3.10 *total precipitable water*—the depth of a column of water (with a section of 1 cm²) equivalent to the condensed water vapor in a vertical column from the ground to the top of the atmosphere (unit: cm or g/cm²).

4. Significance and Use

4.1 Absorptance, reflectance, and transmittance of solar energy are important factors in material degradation studies, solar thermal system performance, solar photovoltaic system performance, biological studies, and solar simulation activities. These optical properties are normally functions of wavelength, which require the spectral distribution of the solar flux be known before the solar-weighted property can be calculated. To compare the relative performance of competitive products, or to compare the performance of products before and after being subjected to weathering or other exposure conditions, a reference standard solar spectral distribution is desirable.

4.2 These tables provide appropriate standard spectral irradiance distributions for determining the relative optical performance of materials, solar thermal, solar photovoltaic, and other systems. The tables may be used to evaluate components and materials for the purpose of solar simulation where either the direct or the hemispherical (that is, direct beam plus diffuse sky) spectral solar irradiance is desired. However, these tables are not intended to be used as a benchmark for ultraviolet radiation used in indoor exposure testing of materials using manufactured light sources.

4.3 The total integrated irradiances for the direct and hemispherical tilted spectra are 896.99 W·m⁻² and 1001.92 W·m⁻², respectively. Note that, in PV applications, an amplitude adjustment of only -0.2 % would be required to match standard reporting condition irradiances of 1000 W·m⁻² for hemispherical irradiance.

4.4 Previously defined global hemispherical reference spectrum (G159) for a sun-facing 37°-tilted surface served well to meet the needs of the flat-plate photovoltaic research, development, and industrial community. Investigation of prevailing conditions and measured spectra shows that this global hemispherical reference spectrum can be attained in practice under a variety of conditions, and that these conditions can be interpreted as representative for many combinations of atmospheric parameters. Earlier global hemispherical reference spectrum may be closely, but not exactly, reproduced with improved spectral wavelength range, uniform spectral interval, and spectral resolution equivalent to the spectral interval, using inputs in [X1.4](#).

4.5 Reference spectra generated by the SMARTS Version 2.9.9 model for the indicated conditions are shown in [Fig. 1](#). The exact input file structure required to generate the reference spectra is shown in [Table 1](#).

4.6 Differences from the previous standard spectra (G159) can be summarized as follows:

4.6.1 Extended spectral interval in the ultraviolet (down to 280 nm, rather than 305 nm),

4.6.2 Better resolution (2002 wavelengths, as compared to 120),

4.6.3 Constant intervals (0.5 nm below 400 nm, 1 nm between 400 nm and 1700 nm, and 5 nm above),

4.6.4 Better definition of atmospheric scattering and gaseous absorption, with more species considered,

4.6.5 Better defined extraterrestrial spectrum,

4.6.6 More realistic spectral ground reflectance,

4.6.7 Lower aerosol optical depth, yielding significantly larger direct normal irradiance, and

4.6.8 Practical definition of the direct irradiance, with inclusion of the circumsolar irradiance within 2.5° from sun center to match measurements made with current pyrheliometers ([7](#)).

5. Technical Bases for the Tables

5.1 These tables are modeled data generated using an air mass zero (AM0) spectrum based in part on the extraterrestrial spectrum of Gueymard ([5](#)), the 1976 U.S. Standard Atmosphere ([8](#)), the Shettle and Fenn Rural Aerosol Profile ([9](#)), the SMARTS radiative transfer code, version 2.9.9, and associated input data files.

5.2 In order to provide spectral data with a uniform spectral step size and improved spectral resolution, the AM0 spectrum used in conjunction with SMARTS to generate the terrestrial spectrum is slightly different from the ASTM extraterrestrial spectrum, Standard [E490](#). The SMARTS and Tables [E490](#) spectra are in general good agreement though they do not have the same spectral interval step sizes, spectral interval centers, or spectral resolution.

5.3 The 1976 U.S. Standard Atmosphere (USSA) is used to provide documented atmospheric properties and concentrations of absorbers. However, some newly documented (and relatively minor) absorbers are taken into consideration in the present standard spectra. See [X1.3](#).

5.4 These terrestrial solar spectral data are based on the work of Gueymard ([1, 2](#)) and Gueymard et al. ([10](#)). Previously defined reference spectra were based on the work of Bird, Hulstrom, and Lewis ([11](#)). The current spectra reflect current (as of 2018) improved knowledge of gaseous absorption, atmospheric aerosol optical properties, transmission properties, and radiative transfer modeling.

5.5 The terrestrial solar spectra in the tables have been computed with a spectral resolution equivalent to that of the wavelength interval. Parameterizations in the SMARTS model are based on high-resolution (2 cm⁻¹) MODTRAN ([3, 4, 12, 13](#)) results subsequently “degraded” or smoothed to the SMARTS2 model wavelength interval.

5.5.1 *Discussion*—This approach emulates the procedure of measuring spectral data with a monochromator by using the wavelength interval equivalent to the spectral passband of the instrument. Results in [Table 2](#) correspond to the native (maximum) resolution of SMARTS.

5.6 To represent favorable conditions for PV energy production and exposure conditions for weathering and durability testing, sites in the National Solar Radiation Data Base ([12](#)) with annual daily average direct normal solar radiation exceeding 6 kWh·m⁻² (or 21.6 MJ·m⁻²) per day were analyzed ([10](#)). The mean aerosol optical depth at 500 nm for these sites was determined to be 0.085. A very slightly

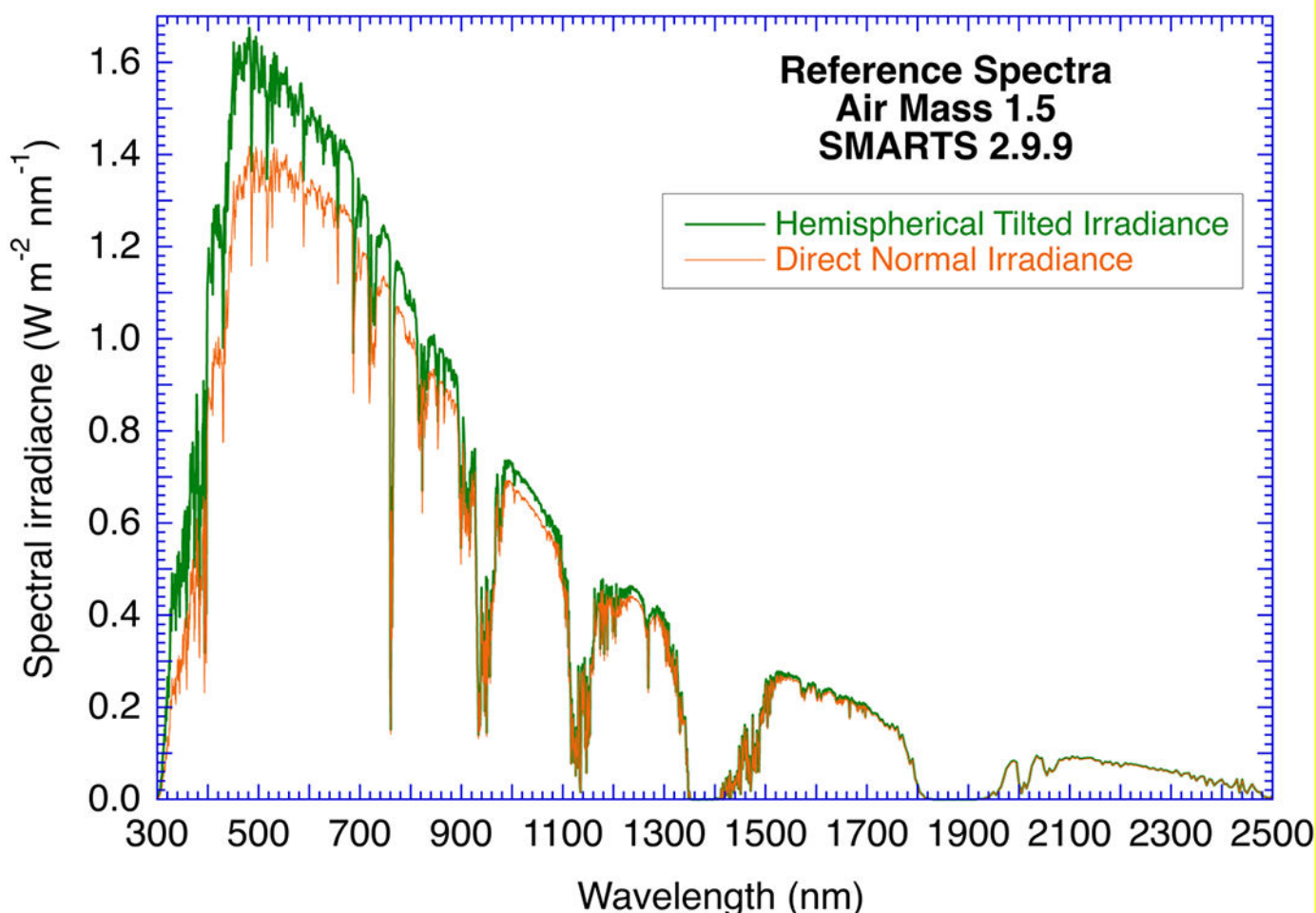


FIG. 1 Plot of Direct Normal Spectral Irradiance (Solid Line) and Hemispherical Spectral Irradiance on 37° Tilted Sun-Facing Surface (Dotted Line) Computed Using SMARTS Version 2.9.9 Model with Input File in Table 1

results in a hemispherical tilted spectrum integrating to 1001.86 W/m², nearly exactly the irradiance used in photovoltaic standard reporting conditions. See X1.2.

5.7 Previous reference spectra were generated using a wavelength-independent albedo of 0.2. The present standards utilize measured wavelength-dependent reflectance data, representing light sandy soil of the southwest U.S. See Fig. X1.1.

5.8 The direct normal spectrum includes the circumsolar spectral irradiance that would be measured with a collimated spectroradiometer or pyrheliometer with a 5.0° field of view (aperture half-angle of 2.5°) representing common commercially available radiometers.

5.9 The profile for the United States Standard Atmosphere of 1976 results in a carbon dioxide volume mixing ratio of 330 ppm. It's current (2018) measured value is about 400 ppm. The latter is the value used in the computation of the reference spectra, as noted in Table 1.

5.10 The selected air mass value of 1.5 for a plane parallel atmosphere above a flat earth corresponds to a zenith angle of 48.19°. The SMARTS2 computation of air mass accounts for atmospheric curvature and the vertical density profile of molecules, which results in a solar zenith angle of 48.236°, or

an equivalent plane parallel atmosphere air mass of 1.50136. The angle of incidence computed by SMARTS2 for the direct beam irradiance incident on a 37°-tilted plane facing the sun is thus 11.236°.

6. Solar Spectral Irradiance

6.1 Table 2 presents the reference spectral irradiance data for direct normal spectral irradiance within a 5° field of view centered on the sun; and hemispherical spectral solar irradiance on a plane tilted at 37° toward the sun, for the conditions specified in Table 1.

6.2 The spectral table contains:

6.2.1 Direct normal spectral irradiance in the wavelength range 280 nm to 4000 nm.

6.2.2 Hemispherical solar spectral irradiance incident on a sun-facing plane tilted to 37° from the horizontal in the wavelength range 280 nm to 4000 nm.

6.2.3 Data in the tables relate to the absolute air mass of 1.5. The direct irradiance contains a circumsolar component for a field of view of 5.8° centered on the sun.

6.2.4 The columns in each table contain:

6.2.4.1 Columns 1, 4, 7: wavelength, nm, 1 nm intervals

TABLE 1 SMARTS Version 2.9.9 Input File to Generate the Reference Spectra

Card ID	Value	Parameter/Description/Variable Name
1	'ASTM_G 173_Std_Spectra'	Header
2	1	Pressure input mode (1 = pressure and altitude): ISPR
2a	1013.25 0. 0.	Station Pressure (mb), altitude (km), and height above surface: SPR, ALT, HEIGHT
3	1	Standard Atmosphere Profile Selection (1 = use default atmosphere): IATM1
3a	'USSA'	Default Standard Atmosphere Profile: ATM
4	1	Water Vapor Input (1 = default from Atmospheric Profile): IH2O
5	1	Ozone Calculation (1 = default from Atmospheric Profile): IO3
6	1	Pollution level mode (1 = standard conditions/no pollution): IGAS (see X1.3)
7	400	Carbon Dioxide volume mixing ratio (ppm): qCO2 (see X1.3)
7a	9	Extraterrestrial Spectrum (1 = Gueymard 2018): ISPCTR
8	'S&F_RURAL'	Aerosol Profile to Use: AEROS
9	0	Specification for aerosol optical depth/turbidity input (0 = AOD at 500 nm): ITURB
9a	0.084	Aerosol Optical Depth at 500 nm: TAU5
10	38	Far field Spectral Albedo file to use (38= Light Sandy Soil): IALBDX
10b	1	Specify tilt calculation (1 = yes): ITILT
10c	38 37 180	Albedo and Tilt variables-Albedo file to use for near field, Tilt, and Azimuth: IALBDG, TILT, WAZIM
11	280 4000 1.0 1361.1	Wavelength Range-start, stop, mean radius vector correction, integrated solar spectrum irradiance: WLMN, WLMX, SUNCOR, SOLARC
12	2	Separate spectral output file print mode (2 = yes): IPRT
12a	280 4000 .5	Output file wavelength-Print limits, start, stop, minimum step size: WPMN, WPMX, INTVL
12b	2	Number of output variables to print: IOTOT
12c	8 9	Code relating output variables to print (8 = Hemispherical tilt, 9 = direct normal + circumsolar): OUT(8), OUT(9)
13	1	Circumsolar calculation mode (1 = yes): ICIRC
13a	0 2.5 0	Receiver geometry-Slope, View, Limit half angles: SLOPE, APERT, LIMIT
14	0	Smooth function mode (0 = none): ISCAN
15	0	Illuminance calculation mode (0 = none): ILLUM
16	0	UV calculation mode (0 = none): IUUV
17	2	Solar Geometry mode (2 = Air Mass): IMASS
17a	1.5	Air mass value: AMASS

6.2.4.2 Columns 2, 5, 8: mean hemispherical spectral irradiance incident on surface tilted 37° toward the sun. E_λ in Watts per square meter per nanometer, $\text{W}\cdot\text{m}^{-2}\cdot\text{nm}^{-1}$.

6.2.4.3 Columns 3, 6, 9: mean direct spectral irradiance within 5.8° field of view incident on surface normal to the sun rays. E_λ in Watts per square meter per nanometer, $\text{W}\cdot\text{m}^{-2}\cdot\text{nm}^{-1}$.

6.3 Fig. 1 is a plot of the direct normal and hemispherical spectral irradiance from the data in Table 2.

TABLE 2 Standard Air Mass 1.5 Direct Normal and Hemispherical Spectral Solar Irradiance for 37° Sun-Facing Tilted Surface

Wavelength, nm	Hemispherical Tilt Irrad, W.m ⁻² .nm ⁻¹	Direct + Circumsolar, W.m ⁻² .nm ⁻¹	Wavelength, nm	Hemispherical Tilt Irrad, W.m ⁻² .nm ⁻¹	Direct + Circumsolar, W.m ⁻² .nm ⁻¹	Wavelength, nm	Hemispherical Tilt Irrad, W.m ⁻² .nm ⁻¹	Direct + Circumsolar, W.m ⁻² .nm ⁻¹
280.0	3.45E-20	2.38E-26	316.0	0.1267	0.0635	352.0	0.5418	0.3329
280.5	9.40E-19	1.08E-24	316.5	0.1615	0.0811	352.5	0.4737	0.2925
281.0	4.59E-18	6.40E-24	317.0	0.1919	0.0968	353.0	0.5441	0.3372
281.5	2.89E-19	2.88E-22	317.5	0.2007	0.1019	353.5	0.5872	0.3652
282.0	1.30E-18	2.89E-21	318.0	0.1712	0.0871	354.0	0.6148	0.3836
282.5	3.82E-18	1.32E-20	318.5	0.1912	0.0971	354.5	0.6230	0.3897
283.0	1.26E-17	6.78E-20	319.0	0.2222	0.1130	355.0	0.6262	0.3926
283.5	2.18E-17	1.45E-19	319.5	0.1981	0.1018	355.5	0.5793	0.3642
284.0	3.35E-16	5.16E-18	320.0	0.2281	0.1179	356.0	0.5770	0.3638
284.5	9.68E-16	2.13E-17	320.5	0.2657	0.1370	356.5	0.5186	0.3278
285.0	2.43E-15	7.37E-17	321.0	0.2526	0.1297	357.0	0.4478	0.2837
285.5	1.30E-14	5.88E-16	321.5	0.2363	0.1218	357.5	0.4884	0.3103
286.0	4.85E-14	2.60E-15	322.0	0.2428	0.1269	358.0	0.4305	0.2742
286.5	2.54E-13	1.87E-14	322.5	0.2236	0.1173	358.5	0.3740	0.2389
287.0	7.91E-13	7.32E-14	323.0	0.2213	0.1159	359.0	0.4864	0.3114
287.5	3.16E-12	3.89E-13	323.5	0.2596	0.1330	359.5	0.6026	0.3864
288.0	1.19E-11	2.65E-12	324.0	0.2912	0.1496	360.0	0.6349	0.4082
288.5	3.90E-11	9.51E-12	324.5	0.3013	0.1561	360.5	0.5544	0.3574
289.0	1.38E-10	3.67E-11	325.0	0.2809	0.1497	361.0	0.5017	0.3243
289.5	5.35E-10	1.56E-10	325.5	0.3395	0.1807	361.5	0.5463	0.3539
290.0	1.70E-09	5.33E-10	326.0	0.4036	0.2109	362.0	0.5166	0.3355
290.5	4.09E-09	1.36E-09	326.5	0.4136	0.2160	362.5	0.6161	0.4010
291.0	1.08E-08	3.83E-09	327.0	0.4103	0.2156	363.0	0.6137	0.4003
291.5	3.71E-08	1.42E-08	327.5	0.3985	0.2108	363.5	0.5643	0.3689
292.0	1.00E-07	4.02E-08	328.0	0.3657	0.1954	364.0	0.6490	0.4252
292.5	1.69E-07	6.91E-08	328.5	0.3819	0.2034	364.5	0.5955	0.3910
293.0	3.86E-07	1.60E-07	329.0	0.4350	0.2311	365.0	0.6043	0.3976
293.5	1.16E-06	4.81E-07	329.5	0.4886	0.2601	365.5	0.7178	0.4733
294.0	2.24E-06	9.21E-07	330.0	0.4906	0.2627	366.0	0.7491	0.4950
294.5	3.37E-06	1.61E-06	330.5	0.4211	0.2276	366.5	0.7385	0.4890
295.0	6.79E-06	3.17E-06	331.0	0.4164	0.2264	367.0	0.7182	0.4767
295.5	1.82E-05	8.05E-06	331.5	0.4225	0.2297	367.5	0.7347	0.4886
296.0	2.90E-05	1.49E-05	332.0	0.4516	0.2450	368.0	0.6678	0.4450
296.5	4.42E-05	2.28E-05	332.5	0.4413	0.2397	368.5	0.6700	0.4474
297.0	5.85E-05	3.03E-05	333.0	0.4412	0.2410	369.0	0.6938	0.4642
297.5	1.34E-04	6.89E-05	333.5	0.4143	0.2282	369.5	0.7526	0.5046
298.0	2.24E-04	1.15E-04	334.0	0.4201	0.2324	370.0	0.7751	0.5207
298.5	2.35E-04	1.20E-04	334.5	0.4673	0.2582	370.5	0.6786	0.4568
299.0	4.39E-04	2.22E-04	335.0	0.4517	0.2498	371.0	0.6817	0.4598
299.5	7.56E-04	3.75E-04	335.5	0.4888	0.2641	371.5	0.7653	0.5172
300.0	0.0009	0.0004	336.0	0.4007	0.2172	372.0	0.6313	0.4275
300.5	0.0012	0.0006	336.5	0.4077	0.2283	372.5	0.6328	0.4293
301.0	0.0020	0.0009	337.0	0.3676	0.2071	373.0	0.6599	0.4486
301.5	0.0030	0.0014	337.5	0.4224	0.2390	373.5	0.5043	0.3434
302.0	0.0032	0.0014	338.0	0.4379	0.2476	374.0	0.5859	0.3997
302.5	0.0050	0.0023	338.5	0.4649	0.2583	374.5	0.5619	0.3841
303.0	0.0083	0.0039	339.0	0.4794	0.2687	375.0	0.5408	0.3703
303.5	0.0103	0.0049	339.5	0.4698	0.2633	375.5	0.7095	0.4868
304.0	0.0105	0.0050	340.0	0.5286	0.3029	376.0	0.6656	0.4575
304.5	0.0137	0.0065	340.5	0.4942	0.2841	376.5	0.6736	0.4639
305.0	0.0187	0.0089	341.0	0.4811	0.2731	377.0	0.7188	0.4959
305.5	0.0216	0.0103	341.5	0.4480	0.2573	377.5	0.8151	0.5633
306.0	0.0205	0.0098	342.0	0.5069	0.2926	378.0	0.8790	0.6086
306.5	0.0242	0.0116	342.5	0.4865	0.2822	378.5	0.8520	0.5910
307.0	0.0325	0.0155	343.0	0.5371	0.3113	379.0	0.7232	0.5026
307.5	0.0417	0.0198	343.5	0.5069	0.2937	379.5	0.6648	0.4630
308.0	0.0437	0.0208	344.0	0.4178	0.2457	380.0	0.6679	0.4660
308.5	0.0485	0.0230	344.5	0.3959	0.2291	380.5	0.7915	0.5533
309.0	0.0487	0.0216	345.0	0.4862	0.2852	381.0	0.7990	0.5595
309.5	0.0525	0.0239	345.5	0.5092	0.3007	381.5	0.6735	0.4725
310.0	0.0557	0.0257	346.0	0.4714	0.2798	382.0	0.5825	0.4094
310.5	0.0780	0.0363	346.5	0.4955	0.2953	382.5	0.4968	0.3498
311.0	0.0984	0.0462	347.0	0.5112	0.3046	383.0	0.4517	0.3186
311.5	0.0983	0.0465	347.5	0.4622	0.2759	383.5	0.4348	0.3072
312.0	0.0986	0.0472	348.0	0.4849	0.2915	384.0	0.4985	0.3527
312.5	0.1106	0.0534	348.5	0.4958	0.2994	384.5	0.6428	0.4555
313.0	0.1202	0.0584	349.0	0.4752	0.2880	385.0	0.6754	0.4794
313.5	0.1191	0.0582	349.5	0.4738	0.2879	385.5	0.6463	0.4595
314.0	0.1390	0.0683	350.0	0.5383	0.3281	386.0	0.5924	0.4219
314.5	0.1314	0.0649	350.5	0.5863	0.3584	386.5	0.6808	0.4856
315.0	0.1527	0.0758	351.0	0.5555	0.3401	387.0	0.6356	0.4541
315.5	0.1347	0.0673	351.5	0.5265	0.3216	387.5	0.6496	0.4649