Effect of Direct Sunlight on Photographic Exposure

This article describes how direct sunlight reaches a photographic subject and how much incident light it provides. Direct sunlight means no clouds or haze between the sun and the subject.

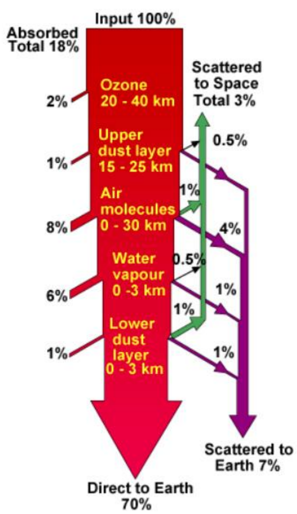
This is a supplement to the conventional exposure value calculations suggested by Sunny 16 (1/ISO seconds at f/16) or EV 15 at ISO 100 (see Exposure value) which is 1/3 stop less than Sunny 16. These two techniques are a way to achieve full sun exposure without the risk of blowing the raw highlights in a digital camera.

Digital images are particularly vulnerable to overexposure because raw files stop recording additional signal at a specific level above middle gray.

Raw highlights can be blown out from too much exposure when there is something in the scene where you want to retain tonality or texture like white feathers, bright white clouds, snow, eggshells, white powder or white cloth. This does not include specular highlights - the reflection of a light source from a smooth surface like water, glass, chrome, white paint or plastic.

There is some interesting information in an electronic book about photovoltaics, the production of electricity from light shining on a crystal. It was created by Christiana Honsberg and Stuart Bowden for Arizona State University's Solar Power Lab. It contains a wealth of information and illustrations about sunlight and solar radiation. The purpose of their study was to quantify the total radiation that could be used for the production of electricity.

Their first illustration in the section on Atmospheric Effects that link shows what happens to sunlight as it reaches the Earth.



Some (18%) of the light is absorbed (converted to heat), 3% of the light is scattered back to space and 7% of the light is scattered back to earth. This includes wavelengths beyond the range of visible light – ultraviolet and infrared.

Some colors are absorbed or scattered more than others. Much of the UV radiation is blocked. We can see the sky as blue when the sun is overhead (at the zenith) and more red as the sun sets.

We cannot use their 18% absorption because it is not limited to visible light. We need to measure visible light for ourselves with an incident meter.

Results from measuring incident light with a Gossen Luna-Pro F over two sunny days from 8 AM through 6 PM were found to correlate closely to a 16.5% absorption assumption for visible light.

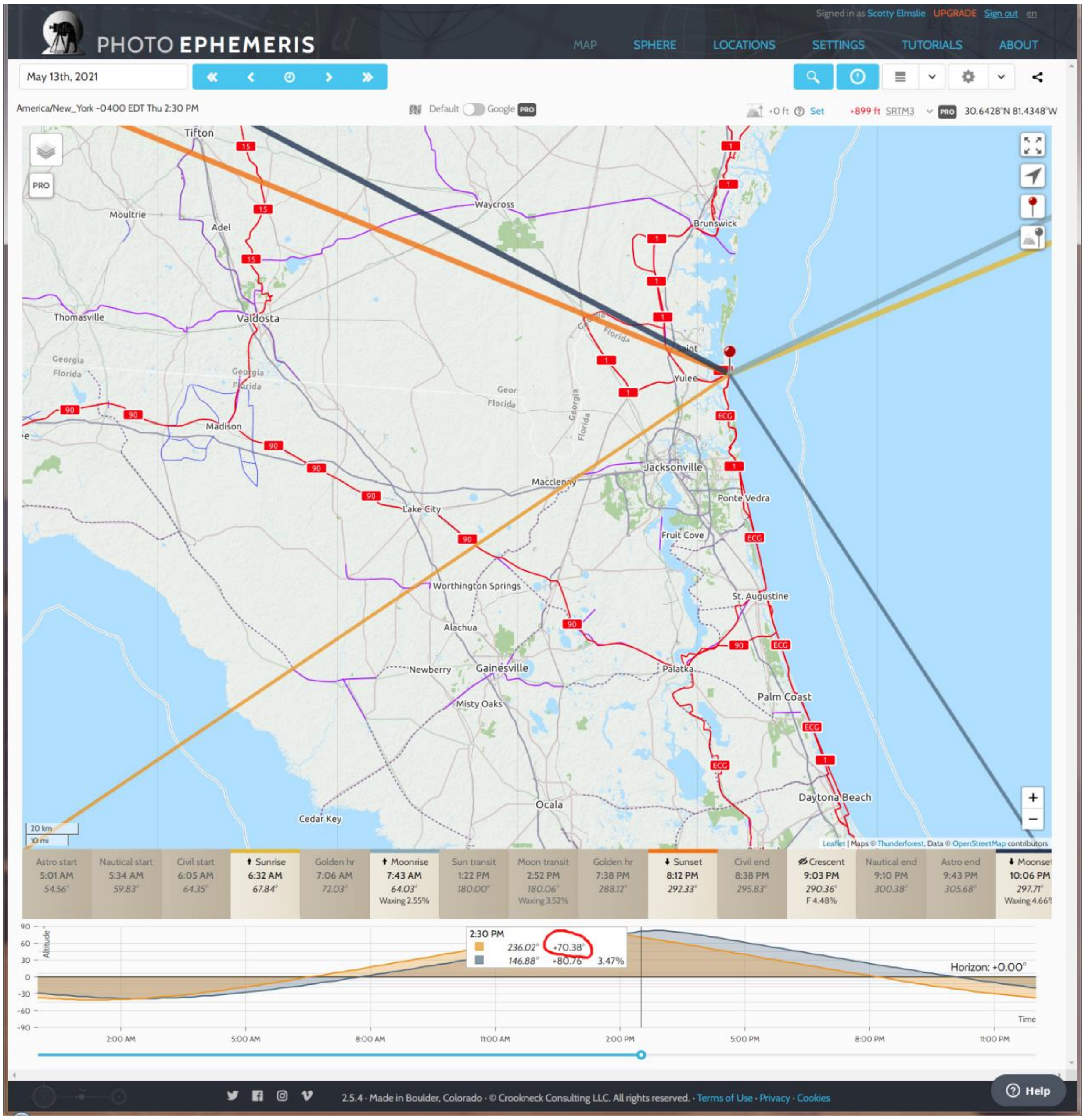
When the sun is not directly above the subject at an elevation of 90° (at the zenith), the direct sunlight needs to pass through more atmosphere. How much more depends on how far it is from the 90° elevation. At an elevation of 0° the sun is either rising or setting which effectively blocks all of the direct sunlight. The lower the sun is in the sky the more light gets blocked.

Elevation °	Direct	10000	LOG(2)	Stops
90	16.5%	8350	13.0276	0.000
75	17.1%	8292	13.0175	0.010
60	19.1%	8095	12.9828	0.045
45	23.3%	7667	12.9044	0.123
30	33.0%	6700	12.7099	**0.318**
15	63.8%	3625	11.8237	1.204

We start from 16.5% and apply an adjustment based on the atmosphere through which the light passes. At 30° elevation (60° from vertical) the light passes through twice as much atmosphere so the 16.5% absorption doubles to 33%.

Base 2 logarithms allow us to calculate the number of additional stops of exposure needed. In this example we need only less than one third of a stop when the elevation is 30°.

The elevation of the sun depends on three factors: the latitude, the date and the local time. All of this can be set in The Photographer's Ephemeris®, a free app from Crookneck Consulting LLC available for the computer, tablet or smartphone.



The elevation at 2:30 PM at the pinned location was 70.38° (19.62° from the zenith). At that time the sun was directly over the Pacific west of Mexico City and south of Phoenix, AZ.

Using the elevation from the ephemeris we can calculate the adjustment needed for the additional atmosphere the light has to pass through. Here is a sample spreadsheet:

	A	B	C	D	E	F
1	To calculate exposure adjustment from elevation:					
2	Absorption=	16.5%				
3	Minimum	13.0276		=LOG(10000*B2,2)		
4	Elevation °	**70.38**		**<< Input elevation here**		
5	Net	17.52%		=B2/SIN((B4)/(180/PI()))		
6	Log(net)	13.0099		=LOG(10000*(1-B5),2)		
7	Additional stops needed	0.02		=B3-B6		
8						

In this case there is no adjustment needed.

But suppose that we were in a different location at a different time and date with a much lower elevation. At Reykjavik, Iceland at 10:30 AM on September 15th the elevation would be 21.37°:

	A	B	C	D	E	F
1	To calculate exposure adjustment from elevation:					
2	Absorption=	16.5%				
3	Minimum	13.0276		=LOG(10000*B2,2)		
4	Elevation °	**21.37**		**<< Input elevation here**		
5	Net	45.28%		=B2/SIN((B4)/(180/PI()))		
6	Log(net)	12.4178		=LOG(10000*(1-B5),2)		
7	Additional stops needed	0.61		=B3-B6		
8						

About 2/3 stop of additional exposure would be enough. But that is optional. You may not need to increase the exposure unless there is some shadow detail and texture you want to record. That is seldom necessary or desirable with daylight photography. With a modern digital camera it is easy to brighten the image by 2/3 stop during post processing if the image was recorded in a raw file.

Adjusting for the air temperature is not included here and neither is the effect of any change in air quality because these would be difficult to quantify.

As your altitude increases there is a change in the makeup of the atmosphere. We can see this in the first illustration. As we get higher the air becomes colder, dryer, less dense and possibly less dusty. Although there is less light being absorbed there is also less sunlight being scattered, less skylight. But these differences are very small over the first couple of miles above sea level. It may amount to less than a tenth of a stop of additional brightness for each mile. Most of our photography takes place at much lower altitudes. If you can breathe easily you can probably ignore it.

An incident light meter pointed directly at the sun can resolve any uncertainties.