



Where will you be on August 21, 2017
— when a total solar eclipse will be
seen from Oregon to South Carolina?

Fred Espenak
& Jay Anderson



Most readers of this magazine associate “2017” with the next total eclipse of the Sun visible from the United States. The anticipation for this event is rapidly increasing and well warranted — after all, it’s been four decades since the Moon’s umbral shadow passed through the “Lower 48.” But even that one, in February 1979, crossed only a handful of states in the Pacific Northwest.

Not so with the total solar eclipse that’s coming on August 21, 2017. The 68-mile-wide, 2,500-mile-long path crosses the breadth of the U.S. from coast to coast and touches a dozen states: Oregon, Idaho, Wyoming, Nebraska, Kansas, Missouri, Illinois, Kentucky, Tennessee, Georgia, North Carolina, and South Carolina.

Weather-wise, August should be a good month for eclipse viewing across the U.S. The Moon’s shadow arrives at a time of year when the peak of the thunderstorm season has passed and sunshine is generous, particularly west of the Missouri River. Although western states offer the most promising weather prospects, with a little care you’ll find good eclipse-viewing sites all across the continent.

This article provides the basics for assessing where you might want to go to witness this grand celestial spectacle. *Sky & Telescope* chose to publish it now, more than 1½ years before the event, because accommodations at choice locations are filling up quickly. Excluding Alaska and Hawaii, more than 300 million U.S. citizens are within a 1- or 2-day drive of the central path, and international interest in this event is already keen. To make your assessment easier, we’ll divide the eclipse path into five geographic regions.

Oregon and Idaho

After first touching down in the Pacific Ocean, the Moon’s umbral shadow takes 28 minutes to travel 2,400



GRAND SPECTACLE Those living in the continental U.S. haven’t seen the Sun’s corona since 1979. Here’s how totality looked from Jinta, China, on August 1, 2008.

FRED ESPENAK



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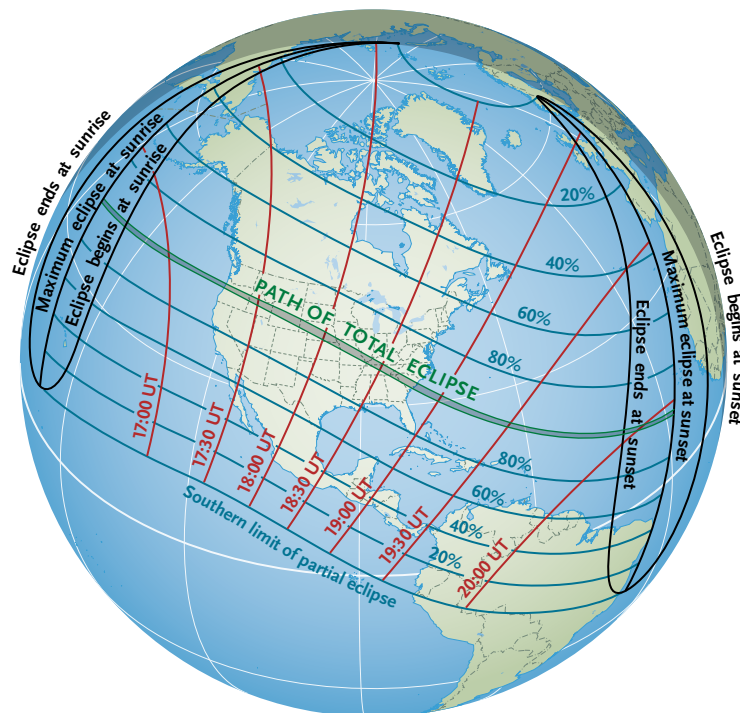
miles before it reaches Oregon's rugged coast. It'll be 10:16 a.m. PDT as the 62-mile-wide shadow track makes landfall at Lincoln Beach, with the midmorning Sun already 39° above the horizon. However, while Oregon's beaches will be first to experience the Moon's shadow, this fogbound coastline and the cold ocean current just offshore are not optimal for eclipse watching.

Rushing inland with a ground speed of 2,400 miles per hour, the Moon's umbra crosses the 3,000-foot-high Coast Range and enters the Willamette Valley. Salem, Oregon's capital, lies 9 miles north of the track's central line and enjoys totality for $1^m 55^s$. The neighboring cities of Albany ($1^m 51^s$) and Corvallis ($1^m 40^s$) are also deep in the path.

The Coast Range forces moist Pacific air upward to cool and condense into clouds. But the 3,000-foot elevation of these peaks is only partially successful at removing the moisture. It takes the much higher Cascade Range, on the east side of the Willamette Valley, to do that. Salem is representative of valley weather with an average cloud amount of 46%.

The shadow scales the 10,000-foot peaks of the Cascade Range before entering the Columbia Plateau — an open plain of farms and dry grasses. The town of Madras (population: 6,400) lies 5 miles south of the centerline, where totality lasts $2^m 3^s$. Ontario, Oregon, lies 8 miles north of the southern limit but is still deep enough in the path to witness $1\frac{1}{2}$ minutes of totality.

After traversing all of Oregon in just 9 minutes, the umbra enters Idaho. Boise, its capital, lies 15 miles outside the path's southern limit. Although Boiseans only get to see a partial eclipse, it's an incredibly deep



TRANSCONTINENTAL EXPRESS Above: The 8,600-mile-long track of the August 21, 2017, total solar eclipse begins at sunrise in the Pacific Ocean and ends at sunset in the Atlantic. About 30% of the path crosses the contiguous United States — the first time that's happened since 1918. Top: Averaging about 68 miles wide, the Moon's umbral shadow will cover about 5% of the area of the contiguous U.S. as it crosses or clips 12 states. Hundreds of millions of Americans will be within a 1- or 2-day drive of totality's path.

S&T ILLUSTRATION, SOURCE: FRED ESPENAK



BIG SKY COUNTRY The surrounding mountain peaks are cloudy, but the Snake River Plain basks in sunshine in this view to the north from the Craters of the Moon National Monument in Idaho — one of the sunniest places along the eclipse path.

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one: 99.6% of the Sun's disk area will be obscured. (This corresponds to an *eclipse magnitude* of 0.994, the fraction of the Sun's diameter to be covered.) Boise still makes a good starting point for the 85-mile drive via Interstate 84 to reach the centerline.

The eclipse track crosses the Sawtooth Range and descends onto the Snake River Plain. Although Idaho Falls is 21 miles south of the eclipse path's central line, it still enjoys 1¼ minutes of totality. Another 30 seconds can be gained by traveling to the path's midpoint.

"Great" eclipse weather should be the norm for the

portion of the path on the lee side of the Cascade Range. Air flowing downward into the valleys warms and dries out, yielding the lowest average cloud cover along the entire track. Airport statistics show that mean cloudiness drops to roughly 25% in both Oregon's Columbia Basin and in Idaho's Snake River Plain. The percent of possible sunshine — the best measure of the true probability of seeing the eclipse — exceeds 80%.

Wyoming and Nebraska

Next the umbra climbs over the Teton Range and enters Grand Teton National Park in Wyoming. The grandeur of the Tetons normally draws many thousands of visitors each summer — adding a total solar eclipse makes the region even more attractive as a travel destination. At Jackson Hole's airport, which lies right on the centerline, totality lasts 2^m 20^s centered on 11:36 a.m. MDT.

The shadow track crosses the Continental Divide in the Wind River Range and descends to the high plains of the Cowboy State. Casper is the largest Wyoming city in the path, and the centerline passes through the south side of the city, giving spectators a total eclipse lasting 2^m 26^s. (Although the longest totality will be seen 980 miles farther east in Carbondale, Illinois, Casper's duration is only 14 seconds shy of it.)

Casper is well served by highways running east and west through the eclipse path. This gives eclipse chasers with mobility the option to move if weather becomes an issue. In fact, the Astronomical League has chosen Casper to hold its annual convention just days before the eclipse for this very reason (astrocon2017.astroleague.org).

Historical data suggest a gradual increase in cloudiness as the eclipse path moves eastward across Wyoming

Two Eclipse-Planning Essentials

Authors Fred Espenak and Jay Anderson have collaborated on many eclipse-related publications for more than 20 years. Now retired, they've reunited to publish *Eclipse Bulletin: Total Solar Eclipse of 2017 August 21*. It's filled with tables, charts, maps, weather data, and eclipse circumstances for more than 1,000 cities in the U.S. and elsewhere. Go to eclipsewise.com/pubs/TSE2017.html for more information.

Separately, Espenak recently published *Road Atlas for the Total Solar Eclipse of 2017*, a book of detailed road maps covering the entire path from Oregon to South Carolina. The track is plotted in 20-second steps, making it easy to estimate the duration of totality from any location along the eclipse path. To learn more, visit eclipsewise.com/pubs/Atlas2017.html.

Both of these useful publications are available from ShopatSky.com.

— J. Kelly Beatty

and into Nebraska. Some of this cloudiness comes from the influx of Gulf of Mexico moisture that dominates the Great Plains in summer and can spread westward to the area around Casper before being stopped by the gradually rising terrain.

The other major cloud producers are Wyoming's mountains, whose dark, forested hills absorb sunlight and frequently blossom with afternoon clouds and thundershowers. Fortunately, such convective clouds tend to arise later in the day, *after* the Moon's shadow will have come and gone. Note that forest fires occur all too often in these Rocky Mountain states during most summers, so be prepared to get out from under the thickest plumes if the fire season is grim.

As the umbra's track enters Nebraska, it leaves behind Wyoming's high-desert environment and gradually descends to the prairie topography of gently rolling grasslands and irrigated farms. Here you'll find a promising cloud climatology, wide-open landscape, and interstate highways that follow the general trend of the shadow's path. The amount of possible sunshine declines a bit traveling west to east, from about 75% to a little under 70%.

August is still thunderstorm season in Nebraska, but storms tend to be limited in areal extent and can be sidestepped by a quick move to a new location. The best conditions are in the western part of the state, where higher terrain and the Rockies' influence limits the influx of Gulf moisture.

Alliance (population: 8,500) lies just north of the centerline and gets a $2^m 30^s$ total eclipse centered on 11:50 a.m. MDT, with the Sun 57° above the southeastern horizon. (Carhenge, a nearby replica of Stonehenge created from vintage American-made automobiles, will

SUNNY SLOPES John Day Fossil Beds National Monument in Oregon provides a colorful vista from which to view the eclipse. The Sun will be 43° above the mountain from this vantage point.

A CENTURY IN THE MAKING

The last time the Moon's umbral shadow crossed the U.S. coast to coast was June 8, 1918. The path was similar, starting in southern Washington and ending in central Florida.



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GROUND ZERO After missing out since 1979, the mainland U.S. is getting two total solar eclipses in a span of 7 years. In fact, the paths for 2017 and 2024 cross at the southern tip of Illinois and southeasternmost Missouri.

make a unique if somewhat tacky location from which to view totality.)

Midway across the Cornhusker State, the city of North Platte lies inside the path about 9 miles from the southern limit. Nevertheless, the duration there is still a respectable $1^m 46^s$, and North Platte's location along Interstate 80 makes it an easy destination to reach. But Grand Island might be an even better location, since it's near both the central line and I-80. The duration there — $2^m 36^s$ — is within 4 seconds of the event's maximum duration.

Lincoln, Nebraska's capital, is located just inside the northern limit (seeing totality for $1^m 13^s$), while larger



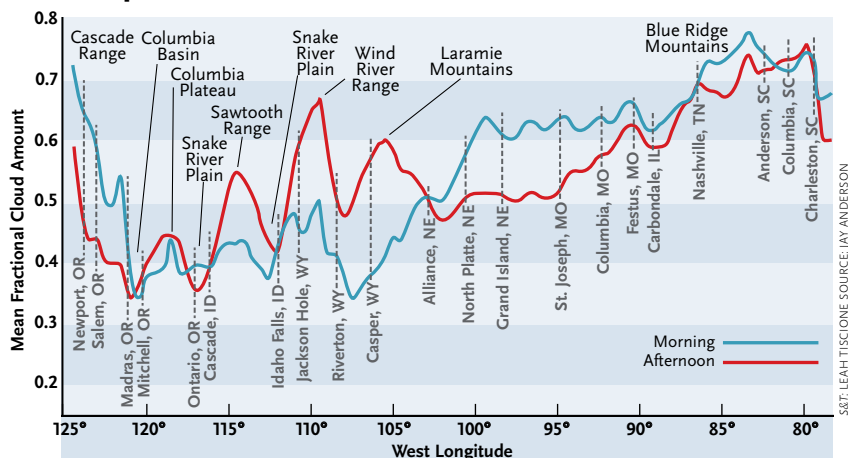
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Omaha, 40 miles north of the track, experiences a partial eclipse with 98.5% obscuration.

Kansas, Missouri, and Illinois

The eclipse track clips the far-northeastern corner of Kansas and crosses the twisty Missouri River three times while entering Missouri. The centerline runs through St. Joseph, where totality lasts 2^m 38^s centered on 1:08 p.m. CDT.

Eclipse Site Cloud Statistics



UPS AND DOWNS Twenty years of satellite data have yielded these plots of morning (blue) and afternoon (red) cloud cover along the eclipse centerline. Use these trends for comparative purposes — not as absolute probabilities. Go to www.eclipsr.ca for more weather statistics.

Location	Clear	Few or scattered	Broken or overcast	Average cloud cover
Newport, OR	18.4	15.6	65.9	63
Salem, OR	36.7	18.3	45.0	46
Redmond, OR	50.4	25.2	24.2	27
Ontario, OR	77.4	6.5	16.1	16
Idaho Falls, ID	42.5	25.7	31.8	32
Jackson Hole/ Teton Village, WY	25.7	42.5	31.8	34
Casper, WY	25.5	36.2	38.2	42
Alliance, NE	32.6	32.8	34.5	35
Grand Island, NE	25.5	28.6	45.9	49
Kansas City/ Platte, MO	21.8	31.4	46.8	49
St Louis, MO	8.4	31.5	60.1	56
Nashville, TN	4.9	42.9	52.1	58
Anderson, SC	4.9	44.5	50.5	50
Charleston, SC	2.8	29.2	68.2	69

Data are derived from cloud-cover statistics gathered 1979–98 at weather stations (mostly airports) nearest to the listed location. The first three columns of values provide the likelihood (as percentages) of specific sky condition at time of eclipse during August. The final column lists the average fraction of the sky (as percentages) covered by cloud at eclipse time.

Eastward from St. Joseph, the protective influence of the western mountains largely comes to an end, and you can expect an environment that typically has a generous supply of subtropical moisture. Along the eclipse track through Missouri and Illinois, average afternoon cloud cover rises steadily toward the east, increasing from under 50% to a bit more than 60%. Yet available sunshine remains relatively constant, perhaps suggesting lots of semitransparent overcast.

Kansas City straddles the southern limit, so the duration of totality there ranges from zero (partial eclipse only) to more than 1 minute, depending on an observer's exact location within the city. A similar situation is true for St. Louis, which the eclipse path's northern limit bisects. As the umbral track follows the Missouri River, it crosses the St. Francois Mountains and descends to the Mississippi and Ohio river valleys and across the Big Muddy Watershed before entering Illinois.

Carbondale, Illinois, holds two unique distinctions. First, the path of the 2017 eclipse has its *greatest duration*, 2^m 40.3^s, at a point about 6 miles south of the town. Second, Carbondale also lies in the path on the next total solar eclipse to cross the U.S., in 2024. So it's no surprise that this small city is billing itself as the "Eclipse Crossroads of America."

Satellite data show that cloudiness decreases a lot from morning to afternoon in Nebraska, Kansas, and Missouri. This poses a bit of a dilemma for site selection, as the time of the eclipse is close to local noon. Keep in mind that the arrival of the Moon's shadow will be heralded by a drop in temperature, suggesting that the morning curve in the graph at upper left might be the more appropriate.

From a purely weather standpoint, the overall best sites along this portion of the path are in western Missouri. But Carbondale lies in the lowlands of the Ohio and Mississippi rivers, giving this community the (statistically) least-frequent cloud cover in the eastern part of the region.

Kentucky, Tennessee, and Georgia

As it crosses the Ohio River, the Moon's shadow enters Kentucky. It's here that, at 1:25:31 p.m. CDT, the axis of the lunar umbra passes closest to the center of Earth — an instant known as *greatest eclipse*. The exact location is a humble sorghum field about 12 miles northwest of Hopkinsville, Kentucky. At that moment the Sun's altitude is 64° and the path of totality 71.3 miles wide. Although the ground speed of the shadow is near its minimum — 1,447 mph — it's still nearly twice the speed of sound.

The duration of totality here is just 0.13 second less than at the point of greatest duration near Carbondale, Illinois, but that distinction seems to make a lot of difference to some communities promoting themselves as the best place to watch the eclipse.

The truth is that any place along the eclipse track



BRAGGING RIGHTS: Low hills and open fields dominate the scenery in Illinois at the site of greatest eclipse. The owner of this field noted that visitors arrived to view the location “every day” — even in 2013, when this photo was taken.

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with a clear sky on August 21, 2017, is a winner.

Kentucky is a landscape of small, rolling hills, tree-lined roads, and numerous farms. As the eclipse track enters Tennessee, the terrain begins to rise, crossing the low hills of the Highland Rim before dropping into the Nashville Basin. The average cloud cover in this stretch ranges between 60% and 70% in satellite data and about 10% lower than that based on airport observations.

Nashville itself lies within the umbral track about 25 miles south of its centerline. At 1:28 p.m. CDT, eclipse watchers in “Music City” will be treated to 1^m 55^s of totality, though they’ll gain 45 seconds more by traveling to the centerline. The eclipse-day percentage of possible sunshine at Nashville is a decent 63% — a promising value for August, though about 20% lower than the best sites in Oregon and Idaho.

East of Nashville, the countryside becomes more heavily forested as it transforms into the ridge-and-valley Appalachians. Unfortunately, Knoxville and Chattanooga both lie outside the path and get 99% partial eclipses. The path of totality also clips the mountainous northeastern corner of Georgia; Atlantans will see a 97% partial eclipse.

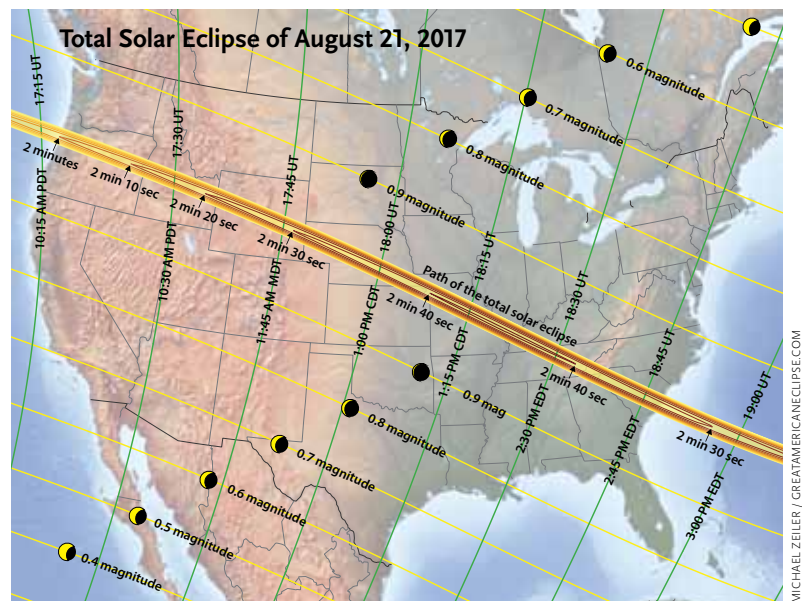
The Carolinas

In the final 14 minutes of its transcontinental journey, the lunar shadow races across North and South Carolina. The downward trend of the terrain’s elevation accelerates as the path approaches the Atlantic Ocean. Along the way, some sizable cities become immersed in the lunar shadow, including Anderson (2^m 34^s), Greenville (2^m 11^s), and Columbia (2^m 30^s). Historic Charleston lies just inside the southern limit, experiencing 1^m 32^s of totality centered on 2:47 p.m. EDT. Head to the centerline, 30 miles to the northeast, to get a duration of 2^m 34^s — still within 6 seconds of the event’s maximum.

Weather prospects are most daunting at the eastern end of the eclipse track. Unlike in the western moun-

tains, there is no strong pattern of windward cloudiness and leeward clearing here. Instead, ever-present humidity, supplied by the tropical Atlantic waters, fuels a patchwork quilt of convective clouds that blossom nearly every afternoon. Fortunately, the cooling that comes with the gradual blocking of the Sun should help to erode the small- and medium-size cloud buildups that might occur on eclipse day.

Average cloud cover in the Carolinas ranges between 60% and 70%, and the likelihood of sunshine at eclipse time hovers around 65%. Prospects are a bit better along the South Carolina coast, courtesy of the afternoon sea breezes that subdue the cloudiness for a few miles inland. Similar benefits might be had along the margins of Lake



NATIONWIDE EVENT Weather permitting, everyone in North America gets to see at least a partial solar eclipse on August 21, 2017. Eclipse magnitude is the fraction of the Sun’s diameter covered by the Moon.



EASTERN EXPOSURE The Blue Ridge Mountains of North Carolina, while providing a stunning vista for the eclipse, are one of the cloudiest areas along the whole of the track.

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Marion, near Santee, where there's ready access to Interstates 95 and 26 if a run for clearer skies is warranted.

Some Final Notes

There's no question that excitement is building about the 2017 eclipse. One key reason: it's close to home for thousands of diehard umbraphiles. And since August 21st occurs during the summer vacation season, this total solar eclipse holds the potential to be seen by more people than any other in history.

Climatology might dictate where early planners head for this event, but in the days ahead of the eclipse, your attention should turn to weather forecasts for August 21st itself. You'll find that information is readily available on the Web, and reliable predictions — reliable enough for serious decision making — can be had a week in advance.

Meanwhile, even if they haven't thronged to the eclipse path, everyone in North America (and in northern South America) will see something grand that day. Looking up from Los Angeles at mid-eclipse — using safe viewing techniques, of course — people will see 62% of the solar disk covered by the Moon. From Boston, it'll be 63%. It'll be worth viewing the partially eclipsed Sun even from such widely separated locations as Anchorage (46%), Honolulu (27%), and Bogotá (24%).

If you're reading this article, you're perhaps already making eclipse plans. But the challenge, for all of us, is to convince family, friends, and neighbors that this isn't just an event for astronomers — it's something

everyone should see. And maybe, just maybe, seeing the 2017 eclipse may inspire some child to become the next Einstein, Newton, or Galileo! ♦

Astronomer **Fred Espenak** coauthored (with Mark Littmann and Ken Willcox) *Totality — Eclipses of the Sun*. He manages the websites eclipsewise.com and MrEclipse.com. Meteorologist **Jay Anderson** (University of Manitoba) has researched eclipse weather forecasts since 1979 and has journeyed worldwide to confirm his predictions in person.



MAGIC DAY This'll be a common scene on August 21, 2017.

FRED ESPENAK