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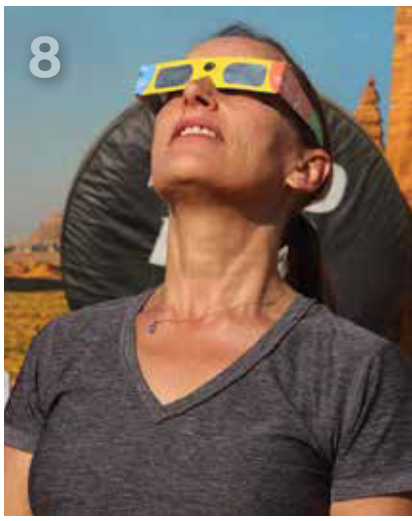
VOL. 52, NO. 4

ON THE COVER

Several distinct coronal streamers can be seen in this image of the Aug. 21, 2017, total eclipse, when solar activity was moderate. BLAKE ESTES

FEATURES

IN EVERY ISSUE



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The big day arrives

Monday, April 8, 2024, offers an eclipse that washes over parts of North America for as long as 4 minutes 27 seconds of totality.
JIM SCHAFF

We finally are getting the astronomical event of the decade (in the U.S.) that countless astronomy enthusiasts have been waiting for. Seven years have passed since Americans witnessed the last total eclipse of the Sun in their homeland, and after this year, another 20 will pass before the next one.

There's something magical about seeing a total eclipse. My background was originally as a deep-sky guy — distant stuff like clusters, nebulae, and galaxies. But as editor of *Astronomy*, I've been fortunate to travel to see a few eclipses and have witnessed a dozen over my career.

Although understanding the solar system's orbital dynamics dates back to the days of Johannes Kepler, the precise alignment of celestial bodies and prediction of the totality-starting flash of diamond ring down to the second never fails to impress. Quite a few first-time eclipse chasers become emotional when totality begins, overwhelmed by a grand spectacle of nature that is so much larger than anything humans do on our little planet.

The issue you hold in your hands constitutes a complete guide to viewing and imaging the eclipse, written by a laundry list of experts — Jay Anderson, Michael Bakich, Steve O'Meara, Rich Talcott, and Michael Zeiler. You will have extensive suggestions, tips, images, maps, and practical guidelines to make the absolute most of your eclipse adventure. Of course, we will all hope for favorable weather everywhere and will follow up here in print and on our ever-expanding website, Astronomy.com, with post-eclipse coverage. Our editors will be out in the field in Texas and Mexico and will look forward to seeing some of you there.

I wish you the best, and whatever you do, enjoy it. Although this one offers a relatively long totality, remember the sage old words of another editor-friend, Norm Sperling — after it's over, every eclipse seems like it lasted eight seconds. So make the most of it and have fun!

Yours truly,

David J. Eicher
Editor

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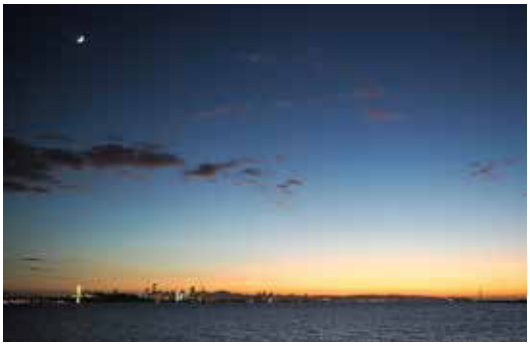


During nautical twilight, stars and planets are visible while the horizon remains clearly discernible. DAVID ABERCROMBIE/FLICKR

We welcome your comments at Astronomy Letters, P.O. Box 1612, Waukesha, WI 53187; or email to **letters@astronomy.com**. *Please include your name, city, state, and country. Letters may be edited for space and clarity.*

Navigating by twilight

I enjoyed Raymond Shubinski's essay, "Twilight's glow is calling," in the November 2023 issue. However, the statement "long ago, sailors out at sea depended on stars for navigation," is misleading.

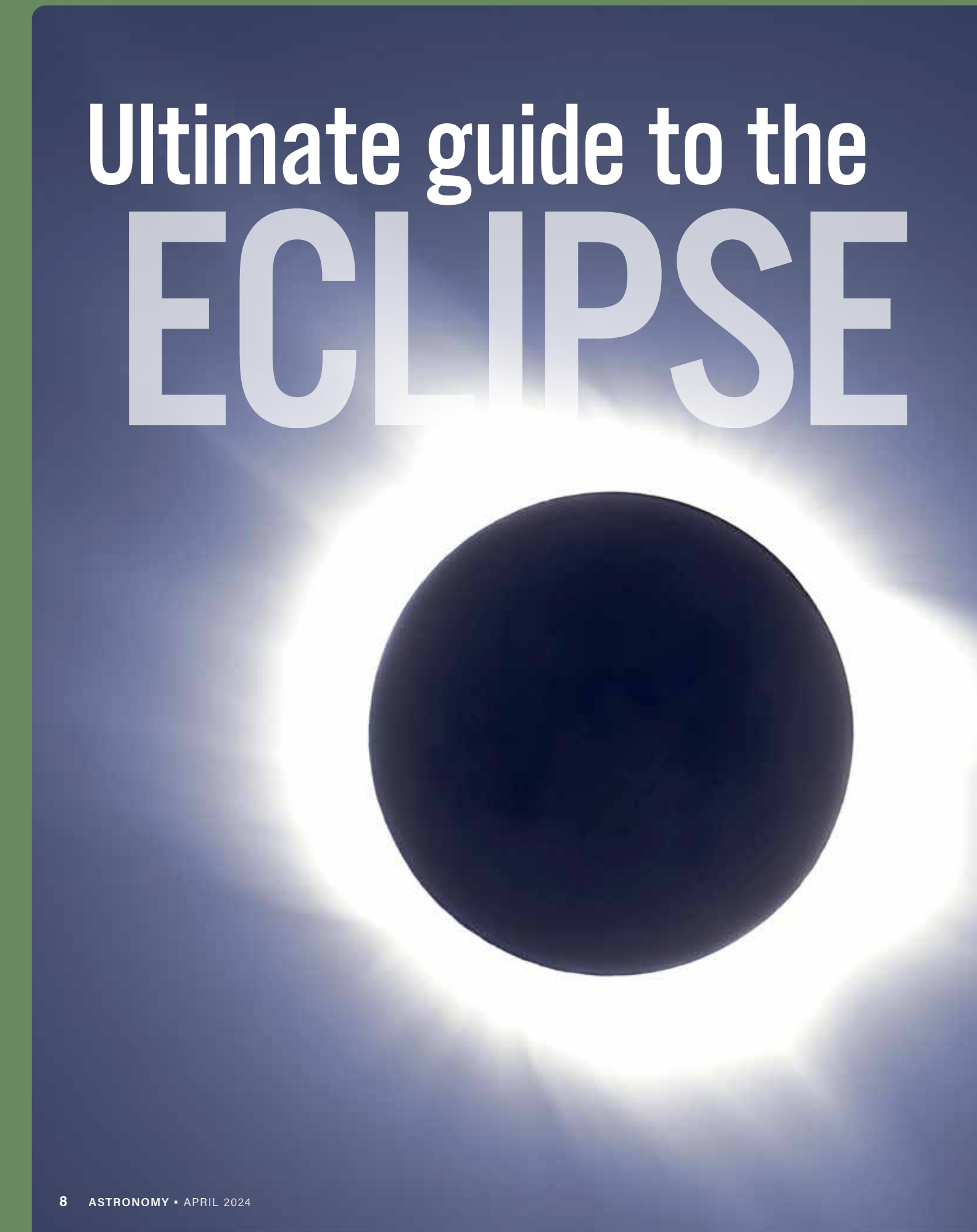
Well into the second half of the 20th century, maritime vessels and aircraft on long flights depended on celestial navigation. GPS was not deployed until 1996. Sailors still need to know how to navigate by the stars — batteries die and electronics fail. To find their location, a navigator measures the height of the Sun, Moon, planet, or star above the horizon, then notes the time and uses spherical trigonometry to calculate the distance from the spot where that celestial object is directly overhead. Nautical twilight is the brief time when the sky is both dark enough to see stars and bright enough to see the horizon. **—Anthony L. Barreiro,** San Francisco, CA

The price is right

I read with delight Ken Wilson's "Toy telescope tryout" (November 2023). I grew up poor, and my only telescope as a child astronomer in the 1970s was a 3-inch cardboard-tube reflector found at a yard sale for $1.25. A few years ago, I spent several hundred times that much on my second telescope, as a grownup with more "toy money."

But one thing that has not changed since my youth is that I am always looking for a good price. Having used telescopes, binoculars, and rifle scopes for over 40 years, I will tell you that the optical quality you can buy today at bargain-basement prices is simply astounding. I recently had the opportunity to test about a dozen different economy telescopes and eyepiece sets, and found that for $100, you can get something that will give a budding astronomer very acceptable views of Jupiter's bands, Saturn's rings, and a host of other celestial objects. In fact, I like one of those little telescopes so much that I frequently grab it instead of my cumbersome 8-inch Dob for a quick look at the heavens. There has never been a better and more economical time to start stargazing than now. **—John Cimbaro,** Lake Worth, FL

Ultimate guide to the ECLIPSE



Want an unforgettable experience? Follow these essential tips. →

BY STEPHEN JAMES O'MEARA

ON APRIL 8, 2024, a total eclipse of the Sun will occur over North America. On this day, the Moon will sail in front of our star and completely cover its luminous face. When it does, the Moon's shadow will sweep across parts of Mexico, the contiguous U.S., and eastern Canada, plunging untold millions of people into daytime darkness for up to 4 minutes 28 seconds — nearly 70 percent longer than during the Great American Eclipse on Aug. 21, 2017. This lengthier totality will allow viewers ample time to absorb one of the most breathtaking spectacles in the heavens.

If you stood in the path of totality during the 2017 eclipse, you have already been anointed by the Moon's shadow and probably don't need convincing to do it all again this April. But you may still benefit from the advice that follows, especially as no two eclipses are ever alike. And for those who haven't experienced totality, this article will help you plan a memorable first voyage into daytime darkness.

Totality is one of the most magnificent and mystifying phenomena in the heavens. Its ethereal beauty can leave a lasting impression of

LEFT: Only during totality is the stunning corona of the Sun visible, such as during the total solar eclipse of March 29, 2006, pictured here. You must be in the path of totality to see this unearthly sight, so plan accordingly. ALAN DYER

BELOW: During the partial phases of the eclipse you need proper eye protection, such as the safe eclipse-viewing glasses the author's wife, Deborah Carter, is wearing, to watch the Moon as it covers the Sun. STEPHEN JAMES O'MEARA

As the partial eclipse progresses, you can observe the Moon taking an increasingly large bite out of the Sun, as well as identify any sunspots (dark spots) that may be visible on our star. Remember to remove your eclipse glasses once totality begins. This is safe when (and only when) the Moon completely blocks the Sun. STEPHEN JAMES O'MEARA

awe and wonder. Add in some bizarre and unique environmental effects, and you can imagine why totality is an experience like no other. But why imagine it? This April, do your best to see this rare spectacle of the ages.

The most important truth

To see totality and experience the sensual wonders accompanying it, you must be in the path of totality — the path where the Moon's dark inner shadow (the umbra) will travel across Earth (see "*Astronomy*'s atlas of totality" on page 36). If you are not in this narrow 124-mile-wide (200 kilometers) path, you will not see the Moon fully cover the face of the Sun, you will not see the Sun's outer atmosphere, and you will not experience the complete fall of darkness or the full range of other strange atmospheric and environmental effects.

The truth of this fact cannot be stressed enough. Anyone *outside* the path of totality will be in the Moon's lighter outer shadow (the penumbra) and see only a partial eclipse. Even if you stand in a 99-percent eclipse zone, you will *not* see the Sun's outer corona; this diaphanous breath of atmosphere is 1 million times fainter than the face of the Sun, so even that remaining 1 percent of sunlight can erase it from view. (Don't be fooled by photographs, which tend to exaggerate the corona's brilliance).

A total eclipse and a partial eclipse are simply not the same. As Annie Dillard so eloquently explains in her 1982 book *Teaching a Stone to Talk*: "Seeing a partial eclipse is very interesting. It bears no resemblance to a total eclipse. Seeing a partial eclipse bears the same relation to seeing a total eclipse as … flying in an airplane does to falling out of one. Although one experience precedes the other, it in no way prepares you for it."

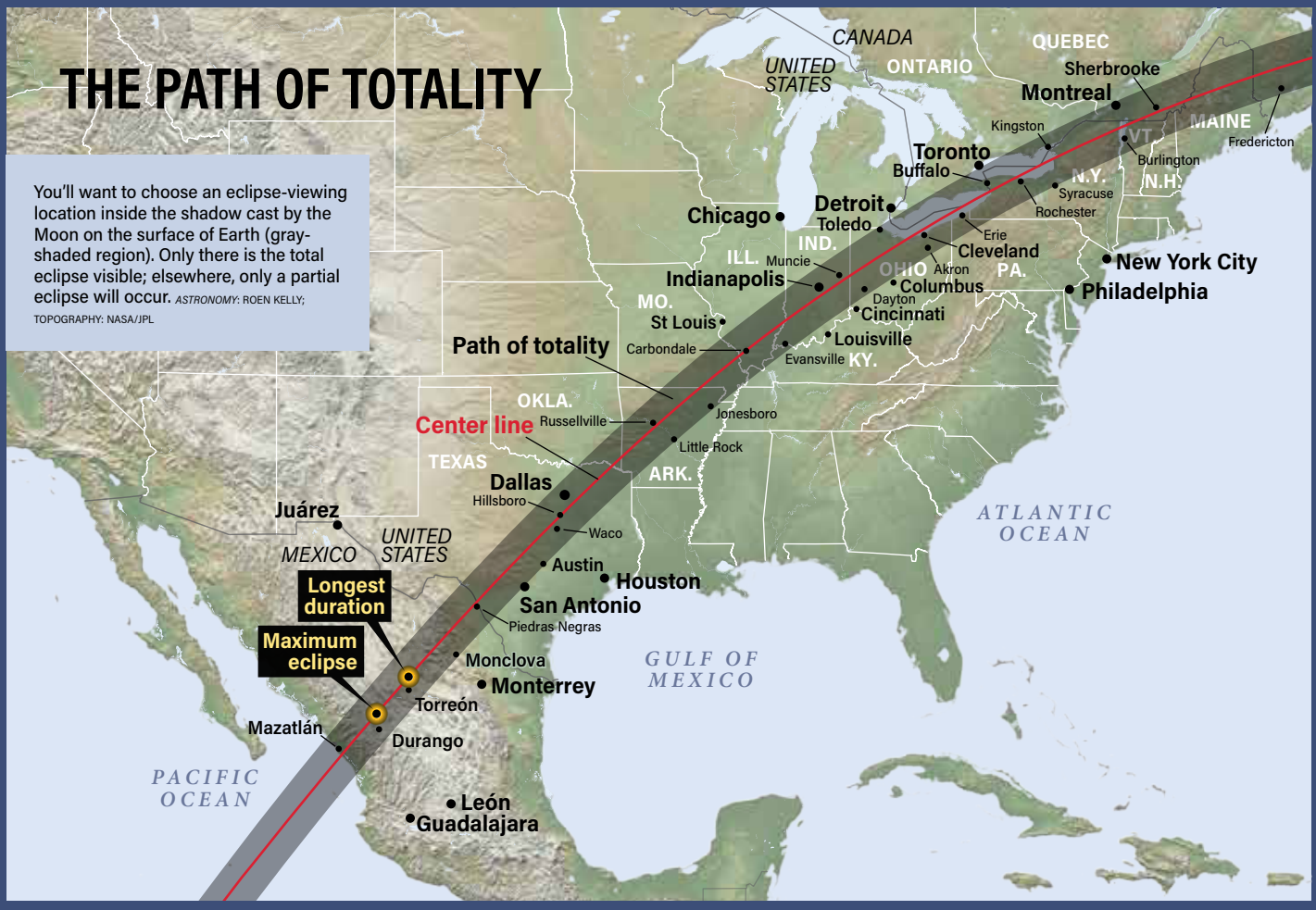
To fully understand these words, you *must* stand inside the path of totality. Standing on the street outside a concert hall during a live performance will not fill one with the same sense of emotion felt inside the hall by those living that intimate experience. Nor will looking at a static photograph of the eclipse fill you with the same wonder as living it.

Where and weather

The first question most eclipse veterans get asked is, "Where are you going to view the eclipse?" Why? Because they will probably know where totality is most likely to occur under clear skies. When it comes to eclipses, location and weather are inextricably linked. Unfortunately, no one can predict with 100 percent accuracy where to see totality without any hindrance from clouds. When selecting an eclipse-viewing site, keep in mind that, while eclipse-weather predictions are usually on the mark (see "Your eclipse weather forecast" on page 20), anything can happen. It's best to always have a backup plan in place before you depart.

By the time you read this article, the

It's essential to keep watching the sky as the eclipse progresses to assess whether inclement weather, smoke, or even patchy clouds might interfere with your view of totality. If confronted with surprise clouds on eclipse day, be prepared to travel to a clearer location. Always head in the direction of blue sky, as long as you stay within the path of totality. STEPHEN JAMES O'MEARA (2)



locations within the path of totality predicted to have the clearest weather (at least in the U.S.) will soon be jam-packed with eclipse-goers. Accommodations at these sites are likely to be scarce or unreasonably expensive. If you still want to see the eclipse from these destinations, it may be wise to avoid traveling to them the night before or the day of the eclipse. As many experienced during the August 2017 totality, traffic gridlocks were a nightmare. If you must travel at that time, then be prepared for potentially long delays. (See the sidebar on page 12.)

Some eclipse chasers opt to avoid the chaos by taking their chances elsewhere. They consider the weather, yes, but they also follow their hearts. If the path of totality sweeps over or near a region of North America that you would really like to visit — whether it be for the landscape, a special event, or proximity to family or friends — then make that region part of your eclipse adventure. If it's family or friends you'd like to see, you can double the joy by sharing the experience with them. Besides, if for some unfortunate reason you cannot escape clouds, you'll still have something exciting to look forward to. Whatever you decide, just make sure you are *in* the path of totality on eclipse day.

> **"Seeing a partial eclipse bears the same relation to seeing a total eclipse as ... flying in an airplane does to falling out of one. Although one experience precedes the other, it in no way prepares you for it."** *— Annie Dillard*

If possible, arrive at your destination a couple of days before eclipse day. Doing so allows you time to monitor satellite data and local weather reports. If the weather prospects at your location look bad, you'll still have time to activate your backup plan. Just consider the time of totality and the distance you'll have to travel to your new destination; again, there may be traffic gridlocks. And as for after the eclipse, April 8 falls on a Monday this year, so you may need to plan for travel delays if your schedule might be affected.

Try your best to observe the eclipse from the *center line* — the line that runs along the path of totality midway between its northern and southern limits (the red line on the map above or, again, see the detailed maps in "*Astronomy*'s atlas of

Severe traffic gridlocks immediately following the August 2017 Eclipse Across America caused travel times to balloon for those returning from the event. The situation is very likely to be the same — if not worse — this April, so be prepared. ALEXANDRAGL/DREAMSTIME.COM

ECLIPSE TRAFFIC

Research following the August 2017 total eclipse showed marked increases in traffic in states along the path. This occurred both in the week leading up to the event as well as immediately following the end of totality. (Many of us who saw that eclipse likely remember best the nightmare traffic on the way home.)

April's eclipse boasts longer totality than in 2017. Several million more people live inside this eclipse path and it crosses numerous major cities, making day trips easier for many. (Want more details? Check out "Upcoming eclipses by the numbers" by Michael Zeiler in our April 2023 issue.) All of this means traffic is likely to become even more congested than in 2017, especially in areas where the road system is not designed to handle a significant influx of vehicles.

This is vital to keep in mind, even if your destination is normally only a few hours away. As cities fill up with eclipse-seekers, roads will become generally busier for everyone. Even errands and commutes in the week beforehand may take longer. Travel times will also likely increase in the hours leading up the eclipse. Then, the number of cars on the roads during totality itself will drop — only to surge immediately after fourth contact.

Regardless of how far you are traveling, plan for it to take several more hours than on an average day — particularly following totality. Make sure you have appropriate supplies to accommodate increased travel times, including water, food, and time-sensitive medications. If you can, stay and watch the partial phases following totality. Not only will you get the "full" eclipse experience, but this also may give traffic some time to clear up as well. — *Alison Klesman*

totality"). The center line marks where totality lasts longest at any given point along the path. The length of totality diminishes the closer you are to the northern or southern limits. The detailed maps on Astronomy.com give the times of totality for different locations away from the center line. Don't discard these locations if that's where clear weather takes you — just don't exit the path of totality.

If you have to travel from your selected location to clearer skies before eclipse day, follow the same advice. Remember to fill up on gas prior to eclipse day and have plenty of food and water on hand — enough for a full day's travel or more. Note that during the 2017 eclipse, some gas stations in prime locations along the path of totality ran out of gas. Many stores in these locations also ran out of bottled water, so be sure to make your water purchases well in advance. Be wise and always use your better judgement along the way. Safety first.

On eclipse day, head to your observing site early — say, at least an hour before the start of the partial phases. In the path of totality, you will experience all the partial phases, with the Moon nibbling away at the Sun until it fully consumes it at the moment of totality. These phases generally last about 90 minutes, which gives you time to monitor the sky for any cloud action before totality arrives. If clouds start to threaten visibility, make your decision to move before the Sun is 50 percent eclipsed. This will give you at least 45 minutes to seek clearer skies. Just make sure the direction you are heading is in the path of totality.

If you are in a situation where you have patchy clouds, it may be necessary to hit the road at a moment's notice, especially as totality approaches. Don't devote all your attention to the clouds overhead, but also scan the landscape for patches of sunlight falling on the ground and head for these clear spots. Look especially for a substantial clearing in the distance or a massive break in the clouds. Time is of the essence, so be prepared to act quickly. Under patchy cloud conditions, always have your vehicle packed and ready to move. And don't worry about setting up and breaking down equipment — you don't need equipment to see or experience the eclipse. All you need is an approved solar filter for the partial phases, and your unaided eyes and maybe binoculars during totality. (Solar filters are an absolute must for all phases except totality.)

But if you cannot escape clouds, you can still experience the effects of totality. You'll still see the fall of darkness, the coronal glow lighting up the clouds, and the many visual and physical changes around you. Much of this is discussed in

Unless you are in the path of totality, you will not see the Moon completely cover the Sun. These images compare a 95-percent partial eclipse (left) with totality (right). Only during totality can you see the Sun's outer atmosphere, the corona. STEPHEN JAMES O'MEARA (2)

Not all clouds spell disaster for a total solar eclipse. This shot shows a partial eclipse underway behind cloud cover. A group of sunspots is visible near the edge of the lunar disk. ALAN DYER

"How to view the eclipse, step by step" on page 14.

Ensuring you enjoy totality

Let's say all is copacetic. It is eclipse day. You are at your final destination under clear skies. You've been enjoying the partial phases safely through your solar filter and the moment of totality is approaching. You may find your heart beating faster and your mind reeling with anticipation as the Moon is about to slam the door shut on the last bead of sunlight.

Now is the time to collect yourself and realize the second most important truth about viewing a total eclipse: You must remove your safe solar filter from your eyes to see totality.

You cannot see totality through a safe solar filter. While you definitely need the filter for the partial phases, when you can see the Sun, during totality there is no Sun! The Moon is completely blocking it. All you see is the dark face of the Moon and the innocuous wisps of coronal light.

Once you remove your solar filter and gaze upon totality, try to exercise restraint and don't interrupt anyone else's personal moment. Actually, you may find that bit of advice unnecessary, because seeing the black hole of the Moon surrounded by coronal "smoke" has the power to idle the brain and leave us raw with emotion and wonder.

Now for the third and final truth: Above all else, make sure you actually see totality with your eyes. Have you heard of Sperling's Eight-Second Law? It comes from *Astronomy* author Norm Sperling, who in the August 1980 issue wrote that no matter how long totality lasts, the universe conspires to make us feel as though it were only eight seconds long. Yet that swift passage of time spent in the Moon's shadow can fill us with an eternity of otherworldly peace. Don't spend totality watching the view through your camera — even if you capture a photo, it won't ever compare to the actual experience. I recommend simply following an old Zen proverb: "Live this moment to the fullest."

Still on the fence?

If you're still debating whether to attend totality, consider this: The next total solar eclipse over parts of the contiguous U.S. and Canada will not occur until Aug. 23, 2044. The next total solar eclipse over Mexico will not occur until March 30, 2052. That's a long time to wait to experience such a life-changing event.

And if you do make a voyage into daytime darkness this April, may the skies rain sunshine on you until totality's darkness descends.

Stephen James O'Meara *is* Astronomy*'s Secret Sky columnist. He has traveled into the path of totality 16 times and been clouded out only once — from a location predicted to have 99 percent clear weather.*

HOW TO

VIEW THE ECLIPSE, *step by step*

From Baily's beads to a potential naked-eye comet, here's what to look for at every stage of the eclipse.

BY RICHARD TALCOTT

PEOPLE HAVE LONG ASSOCIATED good things with the number seven. Sailors navigated the Seven Seas; early scribes established the Seven Wonders of the Ancient World; scientists perceived seven colors in the rainbow; and the first astronomers discovered seven "wanderers" (or planets) in the sky, which gave us the seven days of the week. Even the New York Yankees realized its importance when they bestowed the number seven on Mickey Mantle.

For skygazers this year, the number seven once again heralds a special cosmic alignment: It's been seven long years since the last total solar eclipse to grace the skies above North America occurred Aug. 21, 2017. Now, the Moon once again passes directly in front of the Sun from this continent.

April 8 brings totality to viewers along a narrow path that begins on Mexico's Pacific Coast and then heads north and east, cutting across the U.S. from Texas to the eastern Great Lakes and northern New England. The shadow also touches southern Ontario and Quebec before making its final landfall in the Canadian Maritimes.

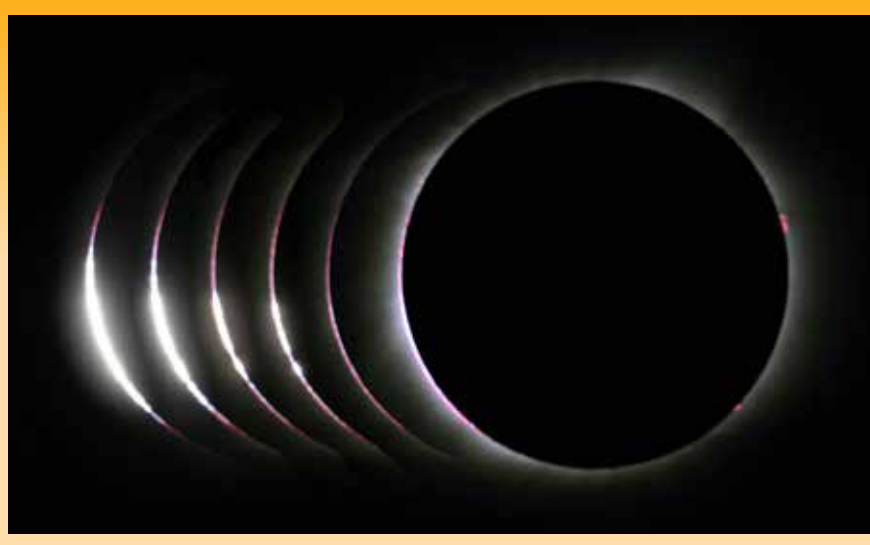
You can find detailed maps of the eclipse path in "*Astronomy*'s atlas of totality" on page 36 and weather prospects in "Your eclipse weather forecast" on page 20. Here, I'll walk you through what you can expect to see throughout the eclipse and highlight both the spectacular and the subtle sights awaiting you April 8.

Eye safety comes first

No one can deny the beauty of a solar eclipse, but seeing one isn't worth endangering your eyesight. Even a momentary look at the Sun with your naked eye during the partial phases risks long-lasting vision problems. A view through binoculars or a telescope can cause permanent blindness in a second or less. And the damage occurs painlessly, so you might not be aware of problems until hours later. The good news: You only need protection during the partial phases — you can view the Sun safely during totality, even with optical aid.

Eclipse glasses are the easiest and cheapest way to protect your eyes. You can typically purchase them for a couple of bucks each. And if you're on a dedicated eclipse tour, the organizers almost certainly will supply glasses to each participant. One note of caution, however: If you saved your eclipse glasses from seven years ago, toss them. The protective coating deteriorates over time and typically doesn't last more than three years.

You'll have to search a bit harder to find a No. 12, 13, or 14 welder's glass. All of these block harmful infrared and ultraviolet light and cut out nearly all visible radiation, leaving just enough to safely view the Sun. The No. 12 delivers a brighter image, which some observers find a bit too intense.



The Moon's shadow falls on Green River Lakes, Wyoming, during the Aug. 21, 2017, solar eclipse in this composite image. BEN COOPER

INSET: Baily's beads appear as a string of pearly lights just before totality begins as the last rays of sunlight stream through low-lying regions on the Moon's limb. As the Moon continues to cover the Sun, the beads disappear until all that is left is one brilliant diamond ring. RODNEY POMMIER

ABOVE LEFT: As the partial phases of the eclipse progress, images of the narrowing Sun will become projected through gaps in leaves. KEVIN CRELLIN

ABOVE RIGHT: Kitchen utensils with holes — like colanders and graters — can become makeshift pinhole projectors. BILL WICKETT

BELOW: The phases of the Aug. 21, 2017, eclipse play out in this sequence of photographs, including the appearance of Baily's beads and the solar corona at totality. BEN COOPER

If you want to view the partial phases in more detail, you'll need either binoculars or a telescope specifically designed for viewing the Sun, or an approved solar filter that fits over the front of your optics. Using a telescope requires the most care. As silly as it sounds, your first task is to find the Sun. Don't use the finder scope — it can blind you as effectively as the main instrument. In fact, you should keep the finder's lens cap on to prevent anyone from accidentally looking through it. Instead, to point your telescope at the Sun, make the shadow cast on the ground by the tube as small as possible.

If you plan on showing the partial phases to a group, consider projecting the Sun's image. This indirect method avoids any danger by having people look away from the Sun instead of toward it. You can repurpose a finder scope or a pair of binoculars for this task, as we explain in "Build a better Sun projector," on page 26. (Or see our February issue for another projector design, one which uses dollar-store lenses.)

It's go time

If you position yourself on the center line, the April 8 eclipse will last between two and three hours from first to fourth contact. That may seem like a lot of time, but as any veteran eclipse chaser will tell you, it seems to go by in the blink of a (well-protected) eye.

Unless you're lucky enough to be able to witness the eclipse from your backyard, plan to get to your site long before the partial phases begin. You don't want to risk being caught in traffic when the eclipse is underway. Arriving early also lets you set up any optical or photographic equipment at a leisurely pace.

If you're viewing with lots of other people, a buzz will sweep through the crowd as first contact approaches. Although predictions made years before foretell the exact moment when the Moon's limb, or edge, first touches the Sun's disk, it's something everyone wants to see for themselves.

From Mexico, the first bite appears on the Sun's right side, near the 3 o'clock position. As the Moon's shadow moves north and east, the point of first contact moves slowly clockwise, reaching the 5 o'clock position in the greater Cleveland area and nearly 6 o'clock from Newfoundland.

The next hour or so is one of breathless anticipation. Although the sky grows darker, it happens at such a languid pace that it's hard to notice. (It doesn't help that your pupils dilate to compensate for the light loss.) An occasional glance toward the Sun will convince you that the

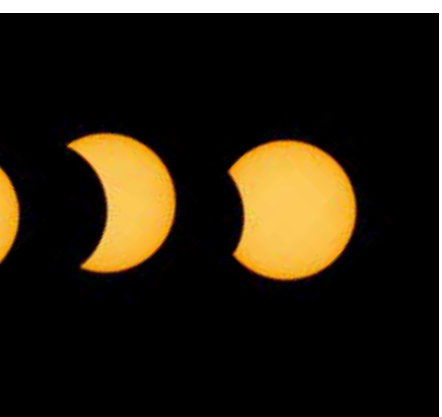
THE SKY ABOVE MAZATLÁN, MEXICO

THE SKY ABOVE CLEVELAND, OHIO

During totality, don't focus solely on the Sun — spend a few seconds taking in your surroundings, as darkness reveals the sky above. Venus will be the most visible object, but further away, you may also see Saturn and Mars, with Jupiter on the Sun's opposite side. Some bright stars may also be visible. And see if you can spot Comet 12P/Pons-Brooks, which may be visible in binoculars — and even has a chance of being a naked-eye object if it is undergoing an outburst. *ASTRONOMY:* ROEN KELLY

celestial machinery remains in good working order. For those viewing with binoculars or a telescope, watch the Moon's dark limb as it swallows sunspots. With the Sun's activity level ramping up as solar maximum approaches, there should be plenty of spots on display.

Once the Moon covers about 75 percent of the Sun's disk, changes to your surroundings are hard to miss. The temperature drops noticeably from its peak around first contact. Consider bringing a small thermometer along to chronicle the change. Shadows also become sharper as the source of light in the sky dwindles to a thin crescent. And for a brief period, colors in the landscape appear more saturated, or intense.



Also take a moment to look beneath any leafy trees or bushes. The tiny gaps between the leaves project lovely images of the crescent Sun onto the ground. If your viewing site lies along the northern part of the track, you may not find any foliage to perform this trick. Don't despair. An ordinary kitchen strainer or a stiff piece of cardboard with holes punched in it serves just as well.

Many members of the animal kingdom won't realize an eclipse is happening overhead and will think darkness has started to fall. Watch for birds seeking a safe place to roost for the "night." Other creatures react in different ways. One of my fondest eclipse memories came during the July 11, 1991, event. Our large group was viewing from a farmer's field in Baja California, and about 15 minutes before totality, we saw a herd of cows heading from their pasture to the barn in anticipation of dinner.

Totality approaches

The pace of change accelerates quickly during the final two minutes before second contact, when totality begins. This is the time to search for shadow bands — an elusive pattern of thin wavy lines alternating between light and dark that ripple across the landscape. Look for them on the ground or the side of a building, or use a white sheet or large piece of poster board as a viewing surface.

Of all eclipse phenomena, shadow bands may be the subtlest. Many experienced eclipse viewers have never seen them, while others consider them a highlight. With so much else going on in the buildup to totality, you might not want to devote precious seconds to hunting for the bands. Instead, try recording a video of them with a tripod-mounted smartphone focused on your chosen viewing surface.

With just a few seconds to go before totality, the Sun's

TOP: The last of Baily's beads dissolve into a diamond ring in this image of the 2017 eclipse. MOSHEN CHAN

ABOVE: The thin pink layer of the Sun called the chromosphere — so named for its colorful appearance — is visible just after totality begins in this shot of the 2017 eclipse. RODNEY POMMIER

edge starts to break up. Mountains along the Moon's advancing limb punch through the thinning crescent while sunlight still streams through lunar valleys. The disappearing Sun looks like a string of pearls, called Baily's beads after 19th-century British astronomer Francis Baily, who described the phenomenon after witnessing the May 15, 1836, annular solar eclipse in southern Scotland.

The Sun's final blaze of glory comes when the multiple beads dwindle to a final jewel — the diamond ring — as sunlight gleams through the deepest valley on the Moon's limb and the solar corona makes its initial appearance. It's worth noting that some observers describe the diamond ring as a precursor to Baily's beads. What order do you see them in?

Hello darkness, my old friend

Totality begins when the Moon's relentless march finally douses the diamond ring. Put your eclipse glasses aside and remove the filters from your binoculars, telescope, and camera. With the Sun's blazing surface, or photosphere, now blocked by the Moon, your eyes and optical equipment are safe from harmful solar radiation.

A few seconds after second contact, you might catch a fleeting glimpse of the solar chromosphere. This thin layer in the Sun's atmosphere lies just above the photosphere and is only about 1,200 miles (2,000 kilometers) thick, so the Moon covers it quickly. As its name implies, the chromosphere appears colorful — a deep red emanating from excited hydrogen atoms.

After the chromosphere departs, everyone's attention turns to the corona. The wispy outermost part of the Sun's atmosphere consists of highly ionized gases that glow pearly white. Delicate streamers extend millions of miles and reach a few times the Sun's diameter. Although many first-time eclipse observers expect the corona to appear faint, it actually shines with an intensity similar to a Full Moon. And it appears brighter as totality advances and your eyes grow accustomed to the darkness. Start your corona observations with the naked eye, then progress to binoculars to search for loops, swirls, and streamers.

No one knows what the corona will look like during totality, but astronomers can make an educated guess. During periods of low solar activity, the corona tends to look asymmetric and sport many streamers. With the Sun now growing quite active, the outer atmosphere should appear round.

Although it might be tempting, don't spend all of totality staring at the corona. Solar prominences along the Sun's limb can be equally spellbinding. These fiery tongues of glowing hydrogen may seem to sprout from the Moon's dark surface. In reality, they have feet planted in the photosphere and reach into the lower corona. Prominences often form loops as the Sun's magnetic field shapes them.

Your surroundings can look equally spectacular. It's worth spending at least a few seconds to take in the big picture. Twilight colors will ring the horizon as

Earth's atmosphere refracts long-wavelength sunlight into the path of totality.

And no eclipse is complete without a view of the brightest planets and stars. Venus will show up clearly some 15° west of the Sun. Gleaming at magnitude –3.9, the brilliant planet should be obvious 10 minutes before totality. Magnitude –2.0 Jupiter lies twice as far east of the Sun as Venus is west and should appear distinct during totality. If you observe from the northern U.S. or Canada, you also might be able to spot Sirius low in the southeastern sky.

Also keep an eye out for a potential guest appearance from Comet 12P/Pons-Brooks. This comet, which has delighted astroimagers with a distinctive horned appearance during outbursts over the second half of 2023, will lie 6° west of Jupiter and 24.5° east of the eclipsed Sun. If it follows projections — never a given with a comet — it could be seen in binoculars. If it is in an outburst, it may even be visible to the naked eye.

Winding down

Almost as soon as totality begins, it seems to end. Third contact — when a second diamond ring appears on the opposite side of the Moon from the first — signifies the conclusion of totality. Put filters back on your binoculars, telescope, and camera at the first hint of the diamond ring. Those using their naked eye can look at the diamond ring — brighter than the first one because your pupils have dilated — for up to five seconds before reverting to eclipse glasses or a filter.

To many observers, the eclipse is now over. Don't fall into that trap. Sure, take a few minutes to celebrate with your companions, but then spend some time watching the partial phases play out in reverse. You might even find yourself appreciating Baily's beads, shadow bands, projected crescents, and razor-sharp shadows better on the eclipse's flipside without the anticipation of totality hanging over you.

Talk among eclipse enthusiasts inevitably turns to the next opportunity to witness totality. Although residents of North America will have to wait until 2044 for their next view, eclipse chasers likely will target Aug. 12, 2026, when totality washes over parts of Spain, Iceland, and Greenland.

Contributing Editor **Richard Talcott** *has witnessed 12 total solar eclipses and expects to enjoy lucky number 13 this April.*

BELOW: Several distinct coronal streamers can be seen in this image of the Aug. 21, 2017, total eclipse, when solar activity was moderate. BLAKE ESTES

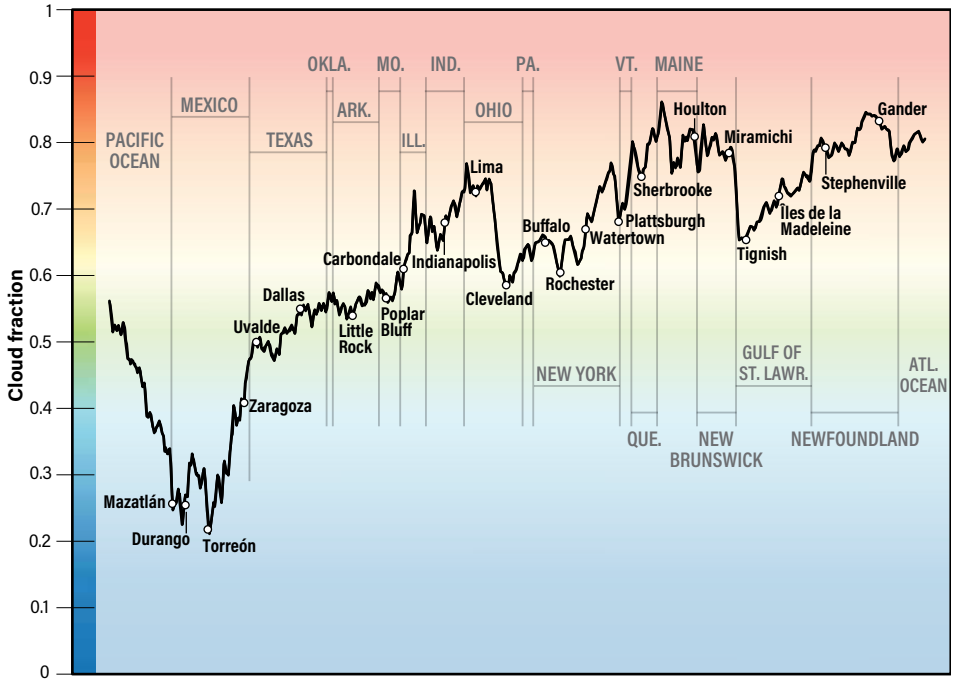
ABOVE: During the Dec. 4, 2021, total eclipse, imaged here from Union Glacier, Antarctica, solar activity was at a minimum, revealing streamers in fine detail. WIJAYA SUKWANTOS

LEFT: The glow of twilight — as well as rain showers — is visible on the horizon as this eclipse-viewing party spots their target in a break in the clouds on Aug. 17, 2021. JIM SCHAFF

YOUR ECLIPSE

The world's leading eclipse meteorologist tells you where to find the clearest skies. BY JAY ANDERSON

CENTER-LINE CLOUDINESS



The average April cloud cover along the center line of the path of totality is plotted here. Data are the same as those used in the cloud-cover map on page 22. Note that cloud cover away from the center line may be quite different and the map should be used for a wider reference. DATA: NASA; GRAPH: JAY ANDERSON

WHEN APRIL 8'S SOLAR ECLIPSE ARRIVES, more than 42 million North Americans living under the path of totality, as well as uncounted millions nearby, will be watching the weather forecast for the prospects of a cloud-free sky. However, those skies could pose a challenge: April is a month that struggles to get out from under the clouds as winter reluctantly gives way to spring.

Useful forecasts can't be made much more than a week ahead, but satellite-based observations of cloud coverage beginning in 1979 provide climate data that point to the best prospects for sunshine. The path of this eclipse spans climates ranging from dry subtropical deserts to snowy spring forests. For the mobile eclipse seeker, the best advice is to go south, where summer weather is most advanced: Mexico and Texas. In April, the average cloud cover along the eclipse track (see graph at left) ranges from roughly 20 percent over the

The terrain north of Torreón, about 43 miles (70 km) inside the eclipse track, is shown here two years before the eclipse — on April 8, 2022. JAY ANDERSON

WEATHER FORECAST

Mexican Plateau around Torreón to more than 85 percent in parts of Quebec and in Newfoundland. (Cloud cover, or cloud amount, is the fraction of the sky covered by clouds.) In the U.S., cloud amounts along the center line range from 48 to 58 percent from Texas through Arkansas, Oklahoma, and Missouri before climbing into the 70 and 80 percent range as the track crosses the Great Lakes and moves into Canada and the northeastern U.S. Fortunately, it's not all gloomy news, as there are oases of sunshine in the northern states and Canada that offer modest promises of clear weather on eclipse day.

The eclipse trek begins!

April is the driest month for a large portion of the Mexican territory covered by the shadow's path. The average monthly cloudiness drops to percentages in the low 20s at Mazatlán and inland, at Durango and Torreón. Beyond Torreón, April cloud cover climbs abruptly as the eclipse track comes under the increasing influence of two factors: moisture from the Gulf of Mexico and the 9,000-foot-high (2,800 meters) peaks of the Sierra Madre Oriental, which force this moisture to colder heights and cause clouds to condense.

The total eclipse of March 9, 2016, didn't let cloud coverage rain on its parade. This photograph was taken with a hand-held Canon DSLR and 600mm lens at Palu, Indonesia. JUDY ANDERSON

Even if your forecast predicts some cloud cover on the day of the eclipse, there's still plenty of hope for a spectacular show. JUDY ANDERSON

The larger part of the cloudiness over Mexico is associated with the subtropical jet stream, which often lies along or atop the eclipse path. On quiet weather days, the jet may bring only thin cirrus clouds. But if a low-pressure system along the California coast is present, the subtropical jet is provoked into much thicker cloudiness while at the same time forming wave clouds and thunderstorms along and downstream of the western Sierra Madres; this will bring patches of overcast skies to the interior Mexican Plateau. Thunderstorms may also form over the mountains, but these will usually come too late in the day to bother the passage of the lunar shadow.

U.S. road trip

As the path enters Texas, elevations drop nearly to sea level along the Rio Grande Valley and the Gulf Coastal Plain. Moisture from the Gulf spreads easily across this lowland, past San Antonio,

JUST YOUR AVERAGE APRIL

The average afternoon April cloud cover shown is derived from NASA's Aqua satellite observations between 2000 and 2021. As one might expect, the further south you go, the bluer the map looks — in other words, more promising skies. DATA: NASA; GRAPH: JAY ANDERSON

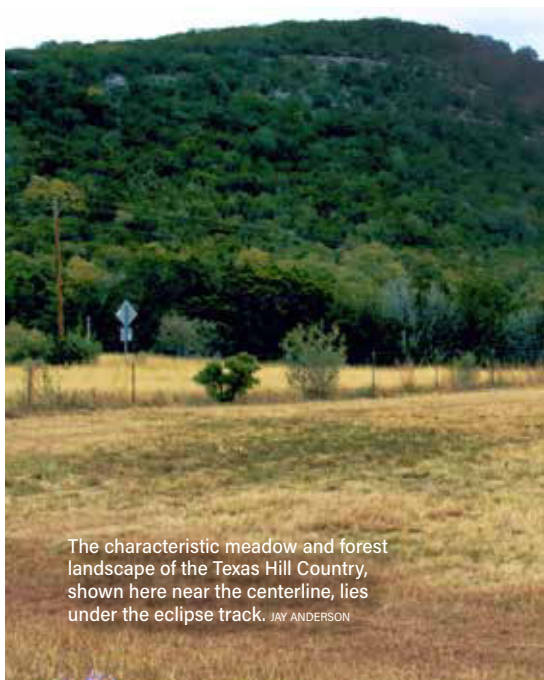
THE REGION FROM JUNCTION TO THE BORDER TOWN OF DEL RIO HARBORS THE MOST PROMISING ECLIPSE-WATCHING SITES IN THE U.S., ALTHOUGH IT COMES AT THE PRICE OF A SIGNIFICANTLY SHORTER ECLIPSE.

before being impeded by terrain that rises onto the Edwards Plateau. This is Texas Hill Country, a rugged landscape of mixed forest and farmland. The map shows that cloud cover over the lowlands at the southern limit of the eclipse is nearly 20 percent higher than at the hilly northern limit, reaching a minimum near Junction, Texas. The region from Junction to the border town of Del Rio harbors the most promising eclipse-watching sites in the U.S., although it comes at the price of a significantly shorter eclipse because of its proximity to totality's northern limit.

Past Waco, Texas, the Moon's path encounters a slow but steady upward climb in cloud cover, rising to about 60 percent along the center line as it reaches Carbondale, Illinois, which also was in the path of 2017's total eclipse. The track is much more likely to be clouded out on the south side over Arkansas' Mississippi Alluvial Plain and the Missouri Bootheel; eclipse seekers in this region should plan on moving onto the Ozark Plateau near West Plains, Missouri.

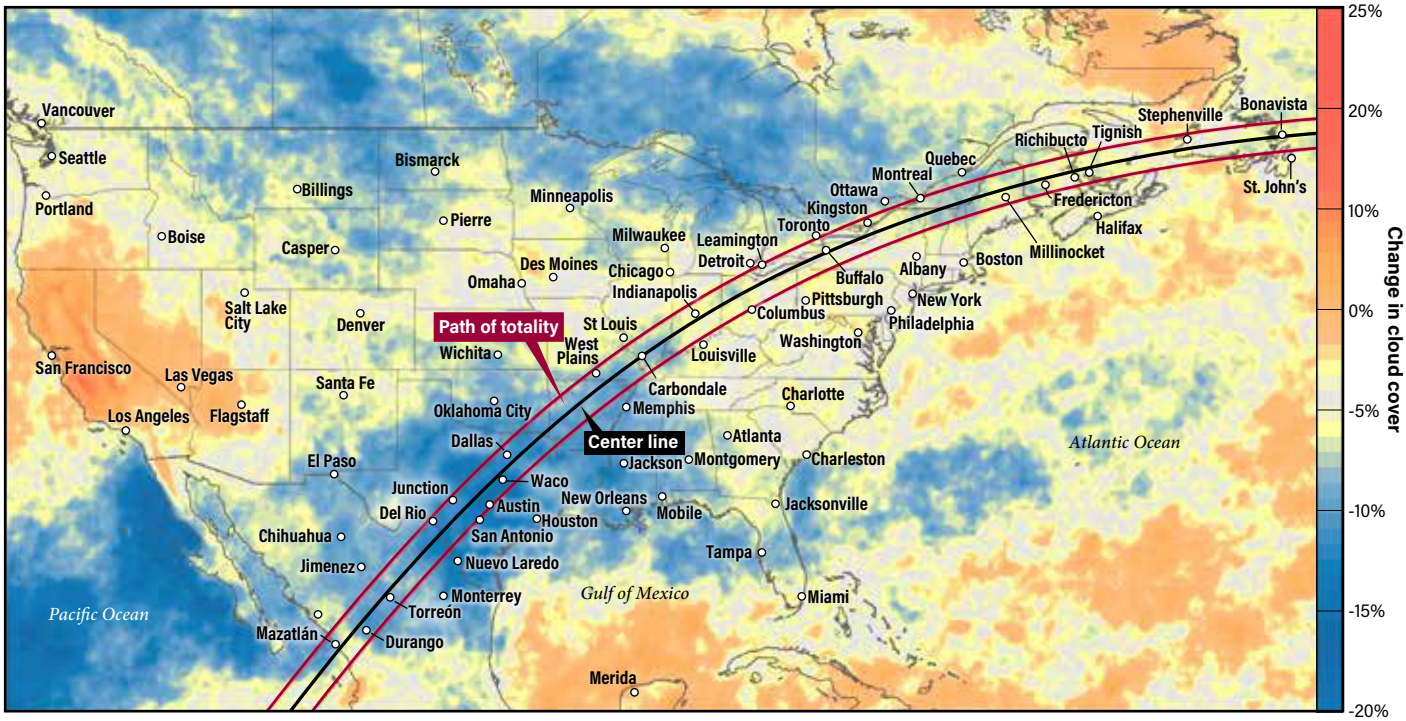
Through Illinois and Indiana, April's center-line cloud cover jumps upward by 10 to 15 percent, reaching a discouraging 75 percent as it moves into Ohio. The track is coming under the increasing influence of springtime low-pressure systems with their large cloud shields and just plain bad weather. At this latitude, we run into the first possibility of snow on eclipse day, though it's only a fraction of the risk of encountering thunderstorms. Cloud cover is evenly spread and does not favor one side of the track over another — at least until the shadow path encounters Lake Erie.

One of the more intriguing aspects of the satellite cloud measurements is the presence of fewer clouds along the south shore of Lakes Erie and Ontario. This reduction — as much as 15 percent — is due to the influence of the lakes, which suppress the formation of convective clouds along their south shores when cold winds blow from the north. Clouds form when the ground is warmed, but the air must travel a short distance inland before the warming takes hold.



The characteristic meadow and forest landscape of the Texas Hill Country, shown here near the centerline, lies under the eclipse track. JAY ANDERSON

EL NIÑO'S IMPACT



El Niño climate patterns warm the surface temperature of the ocean, which can affect normal cloud-cover patterns. The blue areas mapped here show the most decrease in cloud cover from the April norm, while white and yellow remain about the same, and orange areas show an increased cloud cover as a result of El Niño. DATA: NASA; GRAPH: JAY ANDERSON

The effect is quite limited, as the map shows, and so eclipse watchers should also watch the weather and head for the lakes' shores if that cold flow is forecast. This pattern greatly favors Cleveland, and Buffalo and Rochester, New York, as eclipse-viewing sites but doesn't help the northern side of the track over Canada, though there is a small effect at Leamington, Ontario, from Lake St. Clair. For the romantic, Niagara Falls also benefits from the lake effect, though only to a modest extent.

Up north

Past Lake Ontario, the eclipse track encounters the rising terrain in the northern area of the Appalachian Mountains and cloud cover rises once again. Farther on, the shadow arrives at the highest monthly cloud levels anywhere along the track in Maine and New Brunswick, peaking at 85 percent around Maine's Allagash Wilderness Waterway. Cloud amounts are about 10 percent lower over the southern side of the central line, favoring locations near Millinocket in Maine and Oromocto in New Brunswick.

The shadow path reaches the Gulf of

St. Lawrence at Richibucto, New Brunswick, and runs into another sunny oasis where monthly average cloud cover plummets abruptly, falling from 80 to 65 percent at the shoreline. The influence of the Gulf's cold water gives Tignish, on Prince Edward Island's northern tip, the best eclipse weather prospects east of the Great Lakes. Perusal of 24 years of satellite imagery from April 8 reveals that for 10 of those, the eclipse would have been visible within this region — though occasionally through thin clouds.

Beyond the Gulf of St. Lawrence, the late-afternoon shadow reaches Newfoundland and is once again immersed in a heavily clouded landscape. The best prospects on the island are at the water's edge, especially at Cape Bonavista, the last site on land from which the 2024 eclipse can be seen. Previous eclipse-day images show sunny skies in seven of the last 24 years at Bonavista from right along the shore.

El Niño's impact

Cloud-cover statistics are only descriptive if the climate is stable. For the 2024 eclipse, forecasters will have to contend with a wild card: El Niño, the recurring climate pattern in which the Pacific trade winds weaken and cause warm water to build off the west coast of the Americas. As of this writing, El Niño is underway and expected to continue into the spring, raising the question of how representative past data are.

Don't forget about the temperature!

As the track heads northward, wintery conditions become more and more likely. Average April snowfall amounts range between 2 and 4 inches (5 and 10 cm) in New York and Ontario, then climb to 7 to 12 in (18 to 30 cm) through Maine and New Brunswick and to as much as 16 in (41 cm) in Newfoundland. Average overnight lows throughout the northeastern part of the track usually fall below the freezing point in April. *—J.A.*

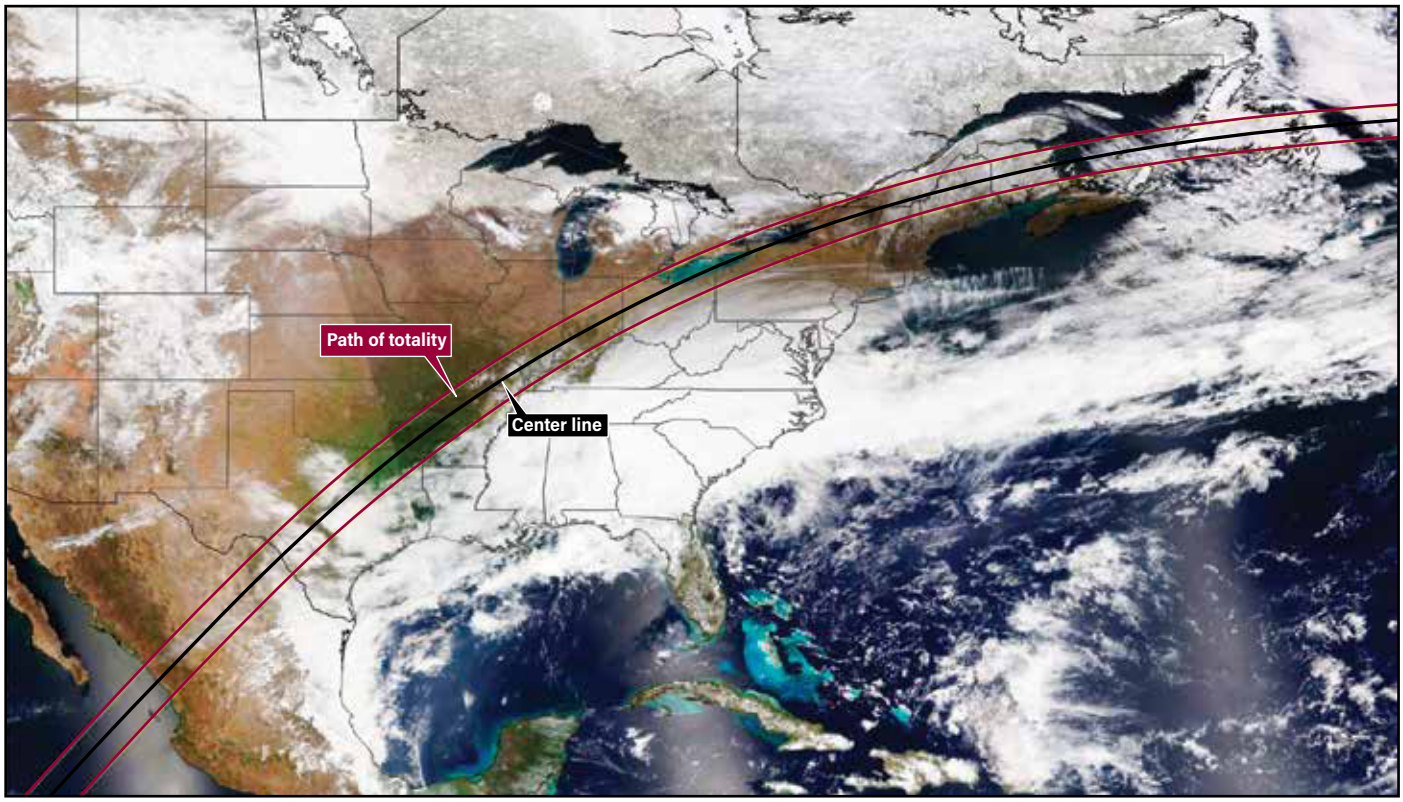
ZAZAMAZA/DREAMSTIME.COM

Satellite cloud data provide insight into the consequences of this phase of the El Niño Southern Oscillation (ENSO). By subtracting average cloud amounts in ENSO-neutral years from the amounts during El Niño years, a cloud-impact map can be derived. (See page 23.) This map is somewhat encouraging, as it shows a considerable decline in cloudiness along the track across inland Mexico and extending as far north as the Arkansas Bootheel and southern Illinois. The maximum impact lies in Texas, where average cloudiness declines up to 14 percent northwest of San Antonio. Over Mexico, cloudiness declines 5 to 10 percent. The southern part of the track in Illinois sees about a 5 percent reduction in cloudiness. For much of the rest of the track, El Niño has little impact.

Thanks to the addition of the ENSO data, the prospects for a view of the eclipse in the southern part of the track are given a boost. It's important to remember, however, that on eclipse day, some areas that are expected to be cloudy will be clear, and vice versa. Turning your attention from climate trends to daily forecasts in the days ahead of April 8 will be essential.

Straight from the source

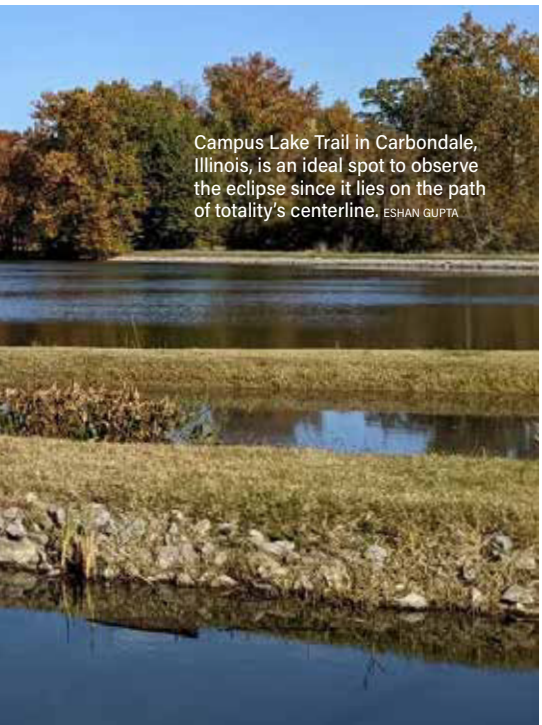
While media outlets throughout North America will be producing eclipse-day weather forecasts, serious eclipse seekers might want to look at the raw output from numerical computer models to form an independent opinion about the reliability of a forecast. There are many places to do this online. Storm chasers gravitate toward the College of DuPage, which publishes both satellite imagery and numerical model outputs



The region of the eclipse track was imaged on April 8, 2023, by the NOAA-20 weather satellite. The breaks in the image are caused by successive satellite overhead passes. Low clouds spreading from the Gulf of Mexico cover much of the Texas part of the track, but most of the remainder is clear. Thin high-level clouds intrude on the eclipse track from Arkansas to Lake Erie; Newfoundland is covered with stratocumulus clouds. Snow on the ground is evident from New Hampshire northeastward.
DATA: JOINT POLAR SATELLITE SYSTEM'S NOAA-20; GRAPH: JAY ANDERSON

at https://weather.cod.edu. During the April 2023 eclipse over Australia and East Timor, many eclipse chasers used Windy.com as their weather source, a resource that can be used worldwide. For site-specific forecasts, SpotWx.com will provide graphs of weather parameters going as far as 16 days into the future.

There are many meteorological models available from a multitude of countries, but the ones you are most likely to encounter are from the U.S., Canada, and Europe. Models — identified by acronyms — come in several flavors, mostly according to the length of the model period. The Canadian Global Deterministic Prediction System (GDPS), the U.S. Global Forecast System (GFS), and the European Center for Medium-Range Weather Forecasts (ECMWF) are long-range models, going out to around 15 days. Shorter-range models with higher resolution, such as the Regional Deterministic Prediction System (RDPS) and the North American Mesoscale (NAM), extend outward for about three and a half days.


Campus Lake Trail in Carbondale, Illinois, is an ideal spot to observe the eclipse since it lies on the path of totality's centerline. ESHAN GUPTA

There are others — the Rapid Refresh (RAP), High-Resolution Rapid Refresh (HRRR), and High Resolution Deterministic Prediction System (HRDPS) — but these are best left for short-range thunderstorm forecasting and don't always give cloud-cover forecasts.

The best advice is to pick two or three of these models and compare their outputs. Don't start relying on them until there is some consistency in the predictions both with each other and with their own previous forecasts, something that will begin about three days ahead of the eclipse. The long-range ECMWF enjoys the reputation of being the best of the models, but it's not freely available like the Canadian and American models (though it can be accessed through Windy.com).

If you are a serious eclipse chaser, there is no reason to miss the 2024 total solar eclipse. Advance planning, attention to the climatology and forecasts, and a willingness to travel should deliver you to clear skies and a phenomenal show. If your time is more limited — it is a work day, after all — keep an eye on the forecasts and make an early start.

Jay Anderson *is a Canadian meteorologist. His forecasts for future eclipses can be found at https://eclipsophile.com.*

BUILD A BETTER SUN PROJECTOR

With a finder scope or cheap binoculars, you can project solar images that far surpass those from pinholes.

STORY AND IMAGES BY MICHAEL E. BAKICH

THE PRACTICE OF using a device to project an image of the Sun is thousands of years old. But if using a pinhole doesn't give the image quality you want, then try this project. The final image will look a lot better.

You'll need a little lumber, a bit of hardware, a tape measure, and a straight-through finder scope — not one that has a right-angle bend. Any finder will do, although the larger the front lens, the more it generally costs, so keep this in mind if you're on a budget.

Tale of the tape

The first measurement you'll make is of the finder's focus distance. Tape a white piece of paper to a board and project the Sun's image on it. Measure the distance between the eyepiece and the paper. Let's call this *T*. You can use inches or centimeters — just be consistent. Then measure the diameter of the Sun's image. We'll call that *D*.

You'll mount everything on a long narrow board (the long arm). Make it *T* inches (or centimeters) long, plus enough extra length for the finder bracket and the thickness of a square piece of wood (the screen board), where the image will be projected.

For my finder, *T* equals 29¾ inches (75.6 centimeters) and *D* equals 4¼ inches (10.8 cm). The extra length needed to attach the finder is 7 inches (17.8 cm). I chose a screen board ¾ inch (1.9 cm) thick, a good thickness because it needs to be attached to the long arm with two screws. Because *D* is 4¼ inches, my screen board is 6 inches (15.2 cm) square.

All this made my long arm 38 inches (96.5 cm) long. I chose to make that piece 2¼ inches (5.7 cm) wide, just a bit more than I needed to accommodate the base of the finder scope. More width just adds unnecessary weight.

Next, attach the finder's base to the long arm with two 1¼-inch-long (3.2 cm)

A simple finder scope mounted to a piece of lumber projects a clear image of the Sun.

bolts. (I used two 1-inch [2.5 cm] bolts and drilled each hole bottom wide enough to hide the nuts attached to the bolts, and deep enough to keep them from protruding.) Then attach the screen board to the long arm with two 1½-inch-long (3.8 cm) screws. Make sure it's perpendicular to the long arm and parallel with the finder's front lens.

Next, attach the finder-scope base, the finder scope, and the screen board to the long arm. Then find the center point where the assembly balances. At that spot, drill a hole and tap it for a ¼"-20 thread. Finally, attach a piece of white paper to the screen board.

You're done. Choose a tripod sturdy enough to carry the weight steadily. Try not to over-tighten the tripod-mounting bolt. If you do strip the threads, home-supply stores sell metal ¼"-20 inserts you can hammer into place.

Or use binoculars

If you don't have a finder scope lying around, you can use binoculars as a projector. I ventured online and spent $24 for a pair of 7x35 binoculars. And they work great! Just make sure that they have a threaded-mounting hole on the front of the bridge, between the barrels. (Most binoculars these days do, typically covered by a cap screw.)

The parts that make this version of the projector are a wooden base, a metal L bracket, a metal plate for the tripod bolt to screw into, and a wooden support for a screen. My binoculars measure 7¼ inches by 5¼ inches (18.4 cm by 13.3 cm). My base is 2 inches wide by 26 inches long (5.1 cm by 66 cm). The Sun's light passing through the binoculars focused 20 inches (51 cm) away. That distance, plus the 5¼ inches of my binoculars, determined the base length I used.

I mounted the L bracket to the base so the ends of the binocular's front lenses were even with the front end of the base. I used wood screws to secure the L bracket to the base and a short ¼"-20 bolt to attach the binoculars to the bracket. The L bracket must hold the binoculars high enough that the Sun's image isn't cut off at the base. To find this height, measure the diameter of the Sun's focused image, take one-half that length, and add ½ inch (1.3 cm) to it.

With two small screws, attach an 8-inch-square (20.3 cm), ¼-inch-thick (0.6 cm) piece of plywood as a projection screen. Paint it white or attach white paper to it.

If you don't have a finder scope, a pair of binoculars works just as well.

Next, attach the plate the tripod's bolt will screw into. I used a 3-inch-long, 1-inch-wide, ¼-inch-thick (7.6 cm by 2.5 cm by 0.6 cm) piece of steel. At its center, I drilled and tapped a ¼"-20 hole for the bolt. Before you mount it, attach the binoculars and the screen board to the base. Then find the balance point. That's where to position the hole in the plate. Finally, attach the metal bar with two screws.

Once you assemble the unit, it's your choice whether to use one side of the binoculars or both (if the images don't overlap). I like the effect of having two Suns visible. Good luck!

Michael E. Bakich *is a contributing editor of* Astronomy *and author of* Your Guide to the 2024 Total Solar Eclipse*, available at MyScienceShop.com.*

SKY THIS MONTH

Visible to the naked eye
Visible with binoculars
Visible with a telescope

THE SOLAR SYSTEM'S CHANGING LANDSCAPE AS IT APPEARS IN EARTH'S SKY.
BY MARTIN RATCLIFFE AND ALISTER LING

The eclipsed Sun stands in the sky above the Grand Tetons during the 2017 total solar eclipse. This month, totality will again carve a path across the U.S. ALAN DYER

APRIL 2024

The Sun goes dark

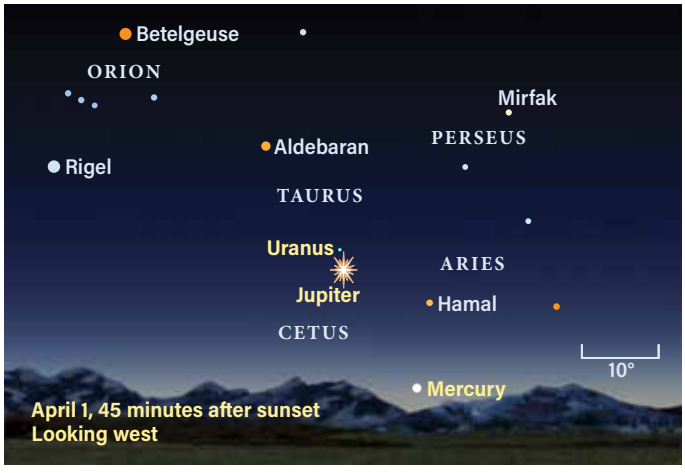
It's here at last! The April 8 total eclipse of the Sun is visible from a narrow track spanning North America from southwest to northeast. While the majority of people across the U.S. will see a partial eclipse of varying degrees, millions will travel to be in that special location inside totality for the spectacle of seeing the corona surrounding the intensely black disk of the Moon as it covers the Sun, an apparent hole in the sky. So sudden is the drop in light during the last 30 seconds leading up to the event — an effect missed from all the partial zones — that totality observers often shout in joy and delight. While a partial eclipse is nice, a total one is the epitome of awe.

In addition to this spectacle, there's an array of planets visible all month, as Jupiter and Uranus lie close together in a conjunction, with Comet 12P/Pons-Brooks located a few degrees from the pair. Venus is sliding behind the Sun, but Saturn and Mars grow in visibility in the pre-dawn sky. They are joined by Mercury, which switches from east to west of the Sun during the month.

We'll start with the total eclipse April 8. It's the second total eclipse in seven years for the U.S., but the next one to cross the contiguous U.S. isn't until 2045. (Of course, there are total eclipses in other parts of the world during this period, including one that touches just three states in 2044.) Inside the track of totality, observers get the rare and enchanting view of the corona, and with the recent increase in solar activity its appearance will be very different to that observed in 2017.

The track of totality makes landfall on the Mexican Pacific coast at Mazatlán, where totality lasts 4 minutes 17 seconds. The longest duration of totality, lasting 4 minutes 28 seconds, occurs inland near Nazas, Durango, in Mexico at 1:17 P.M. MCDT. Ten minutes later, the shadow crosses the U.S. border near Eagle Pass, Texas, and heads toward Dallas-Fort Worth. The local population

Quick switch



Mercury starts the month in the evening sky but ends it in the morning. Jupiter and Uranus (which requires binoculars) remain visible for a shortening window after sunset all April. ALL ILLUSTRATIONS: *ASTRONOMY*: ROEN KELLY

OBSERVING HIGHLIGHT

MARS and **SATURN** meet in a conjunction that brings them 0.5° apart on April 10.

southeast of these cities (which host some 7 million people) will experience 4 minutes 23 seconds of totality starting at 1:40 P.M. CDT.

The eclipse track proceeds northeast at about 1,600 mph, crossing Oklahoma, Arkansas, Missouri, and into southern Illinois. There it passes over Carbondale, where the August 2017 eclipse was also visible.

The track passes over Indianapolis, where totality begins at 3:06 P.M. EDT, then Cleveland, where totality starts at 3:13 P.M. EDT. After crossing Lake Erie (missing Toronto by a few miles), the shadow of totality reaches Buffalo and Rochester in New York at 3:18 P.M. and 3:20 P.M. EDT, respectively, then crosses Lake Ontario. It reaches the final large city in its path, Montreal, at 3:26 P.M. EDT, before leaving Canada at Newfoundland and Labrador.

During the total phase of the eclipse, spend a moment looking for planets that will be visible. Most obvious is Venus, 15° southwest of the Sun. The next brightest planet, Jupiter, lies nearly 30° northeast of the Sun and should be easy to spot. Mars and Saturn will be more difficult, shining at magnitude 1.2 and 1, respectively, located about 35° southwest of the eclipsed Sun. Now turn

— *Continued on page 34*

RISING MOON | Breaking down

THE WAXING GIBBOUS Moon is chock-full of interesting sights. You can even start your observing session before dark, when the light blue sky reduces glare. Take in Tycho's long rays as well as the large expanse of Mare Imbrium and eye-catching Sinus Iridum on its northwestern portion. Then follow that up with the prominent crater Copernicus' splatter.

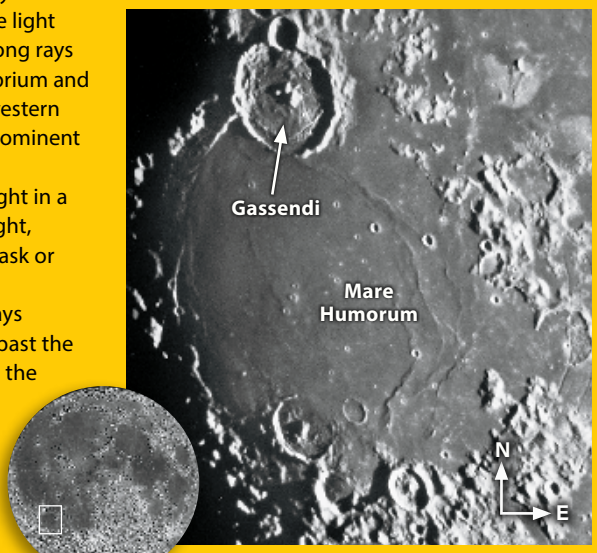
At night the Moon is remarkably bright in a scope. A filter is best to cut down the light, though reducing the aperture with a mask or wearing sunglasses can help a lot, too.

On the evening of the 19th, a few days before Full, the sunrise line has moved past the fascinating crater Gassendi, perched on the north edge of the modest Mare Humorum in the lunar southwest. Formed by an impact event, Gassendi is a 70-mile-wide circular feature tilted down toward the center of the Sea of Moisture. The slumping of the lava-filled basin dragged the surrounding terrain down with it.

Gassendi has multiple peaks and slumped walls, characteristics of large craters. You can even see how the prominent crater on its north side formed afterward and pushed this material inward. The arcs and rilles inside the main ring to the south and southeast are leftovers of floor fracturing, where the up-and-down movement of the crust caused cracks like those you might find on a pie crust. Lava welled up from underneath, covering half the floor — though not as deep as the fully coated crater Plato far to the north.

A contemporary of Galileo and Kepler, Pierre Gassendi of France was a supporter of Copernicus' heliocentric theory.

Gassendi

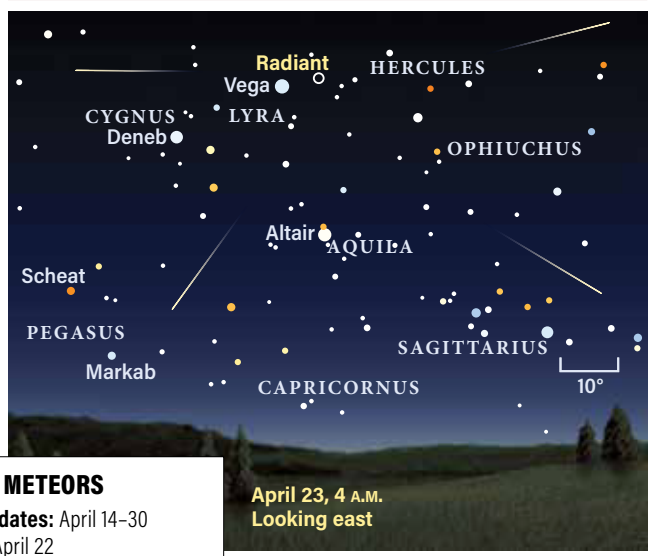


Gassendi sits at the northern edge of the circular Mare Humorum, the Sea of Moisture.

CONSOLIDATED LUNAR ATLAS/UA/LPL. INSET: NASA/GSFC/ASU

METEOR WATCH | Only the brightest prevail

Lyrid meteor shower



The Lyrids peak late on April 22; watch them overnight and into the next morning, when the radiant will be highest.

LYRID METEORS
Active dates: April 14–30
Peak: April 22
Moon at peak: Waxing gibbous
Maximum rate at peak: 18 meteors/hour

THE ANNUAL LYRID METEORS are strongly affected by a Full Moon this month and not very favorable. Active from April 14–30, the shower peaks on the night of April 22, just one day before Full Moon. The Moon's light causes enough of a glow to block out fainter meteors, leaving only a handful of bright ones visible. The radiant rises in late evening and stands about 30° high at local midnight. With the Moon in Virgo and visible all night, the typical zenithal hourly rate of 18 meteors per hour will likely be reduced to half a dozen per hour at most.

Like most meteor showers, the best time for the Lyrids is in the pre-dawn hours, when Lyra and Hercules stand high in the sky.

STAR DOME

HOW TO USE THIS MAP

This map portrays the sky as seen near 35° north latitude. Located inside the border are the cardinal directions and their intermediate points. To find stars, hold the map overhead and orient it so one of the labels matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

The all-sky map shows how the sky looks at:

midnight April 1
11 P.M. April 15
10 P.M. April 30

Planets are shown at midmonth

MAP SYMBOLS

- Open cluster
- Globular cluster
- Diffuse nebula
- Planetary nebula
- Galaxy

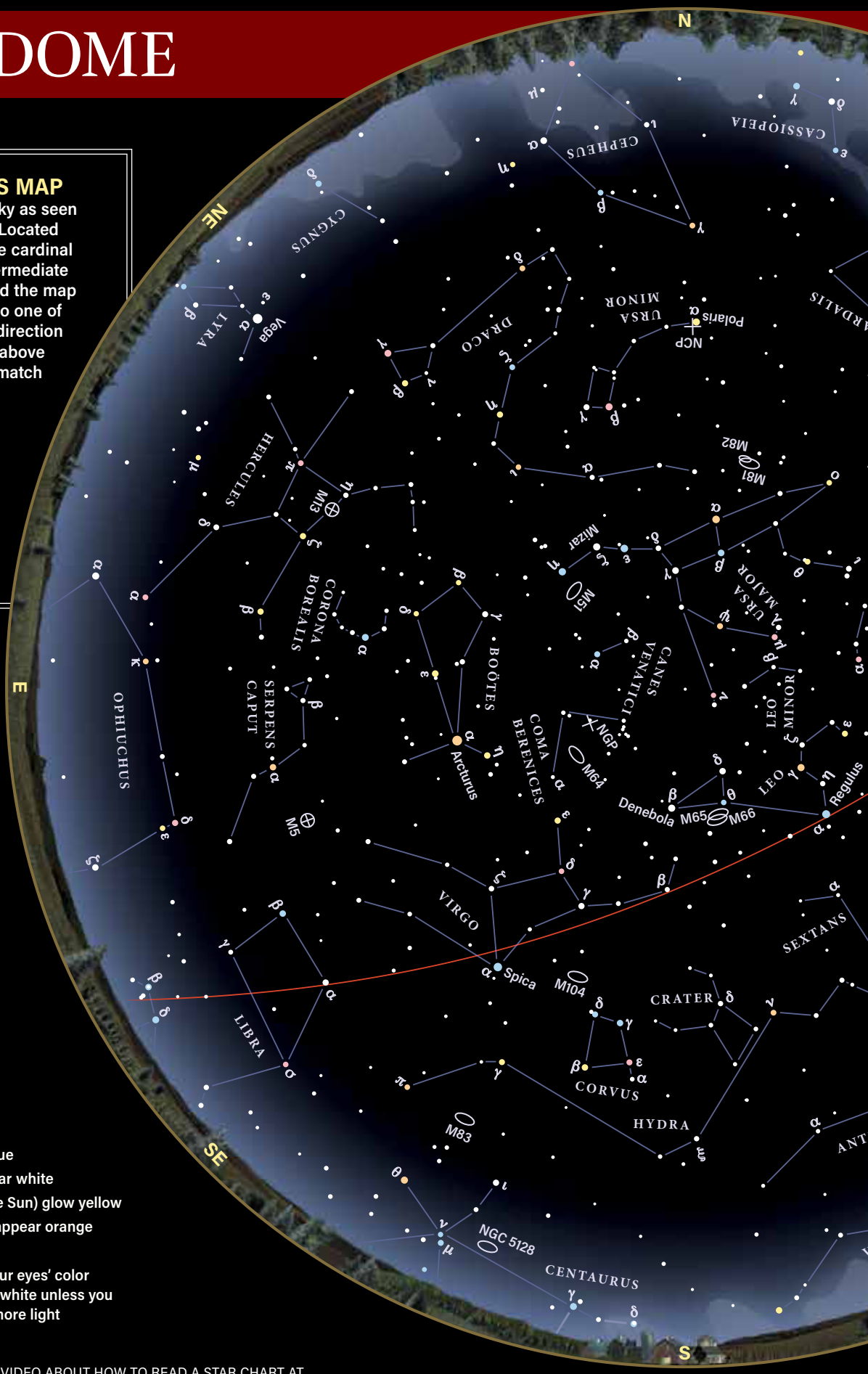
STAR MAGNITUDES

- Sirius
- 0.0
- 1.0
- 2.0
- 3.0
- 4.0
- 5.0

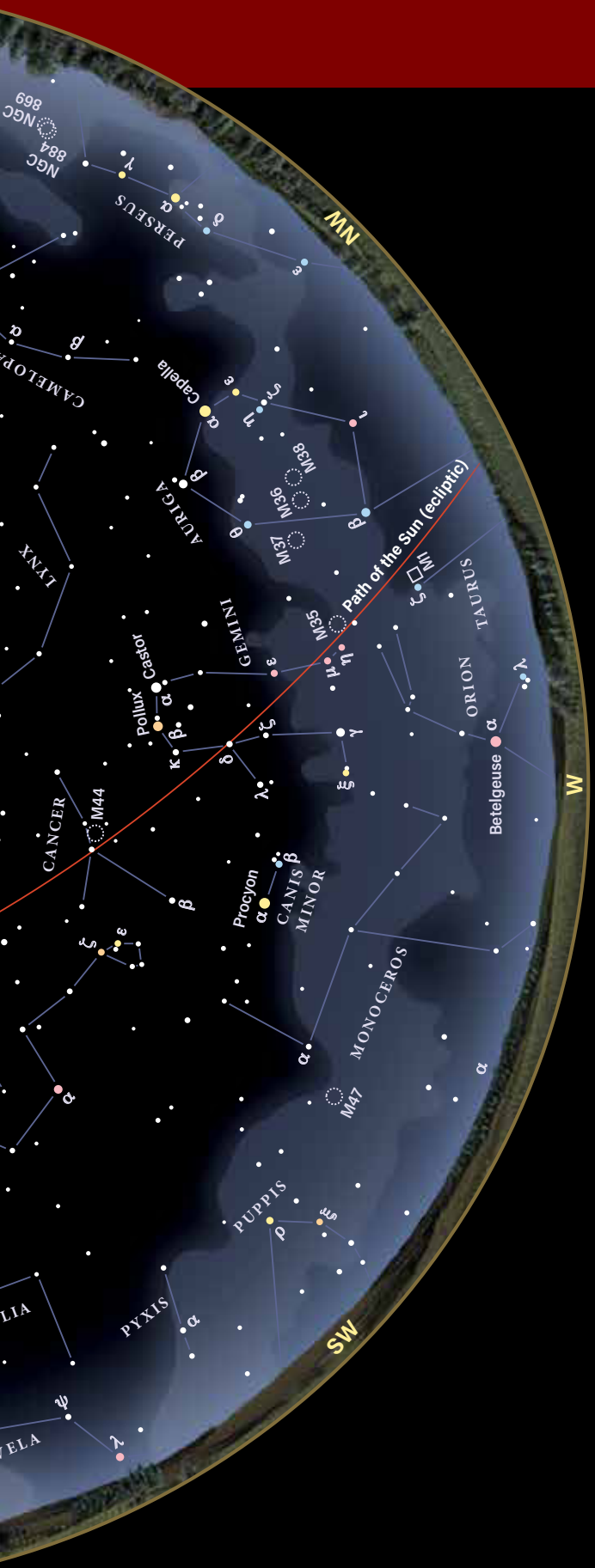
STAR COLORS

A star's color depends on its surface temperature.

- The hottest stars shine blue
- Slightly cooler stars appear white
- Intermediate stars (like the Sun) glow yellow
- Lower-temperature stars appear orange
- The coolest stars glow red
- Fainter stars can't excite our eyes' color receptors, so they appear white unless you use optical aid to gather more light



BEGINNERS: WATCH A VIDEO ABOUT HOW TO READ A STAR CHART AT **www.Astronomy.com/starchart.**



APRIL 2024

SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

ILLUSTRATIONS BY *ASTRONOMY*: ROEN KELLY

Note: Moon phases in the calendar vary in size due to the distance from Earth and are shown at 0h Universal Time.

CALENDAR OF EVENTS

1 Mercury is stationary, 4 P.M. EDT

Last Quarter Moon occurs at 11:15 P.M. EDT

4 Asteroid Pallas is stationary, 3 P.M. EDT

5 The Moon passes 2° south of Mars, midnight EDT

6 The Moon passes 1.2° south of Saturn, 5 A.M. EDT

7 The Moon passes 0.4° south of Neptune, 4 A.M. EDT

The Moon passes 0.4° north of Venus, 1 P.M. EDT

The Moon is at perigee (222,979 miles from Earth), 1:51 P.M. EDT

8 Asteroid Herculina is at opposition, 8 A.M. EDT

New Moon occurs at 2:21 P.M. EDT; total solar eclipse

10 The Moon passes 4° north of Jupiter, 5 P.M. EDT

The Moon passes 4° north of Uranus, 8 P.M. EDT

Mars passes 0.5° north of Saturn, 11 P.M. EDT

11 Mercury is in inferior conjunction, 7 P.M. EDT

15 First Quarter Moon occurs at 3:13 P.M. EDT

18 Asteroid Juno is stationary, 11 A.M. EDT

Mercury passes 2° north of Venus, 7 P.M. EDT

19 The Moon is at apogee (252,043 miles from Earth), 10:10 P.M. EDT

20 Jupiter passes 0.5° south of Uranus, 4 A.M. EDT

22 Lyrid meteor shower peaks

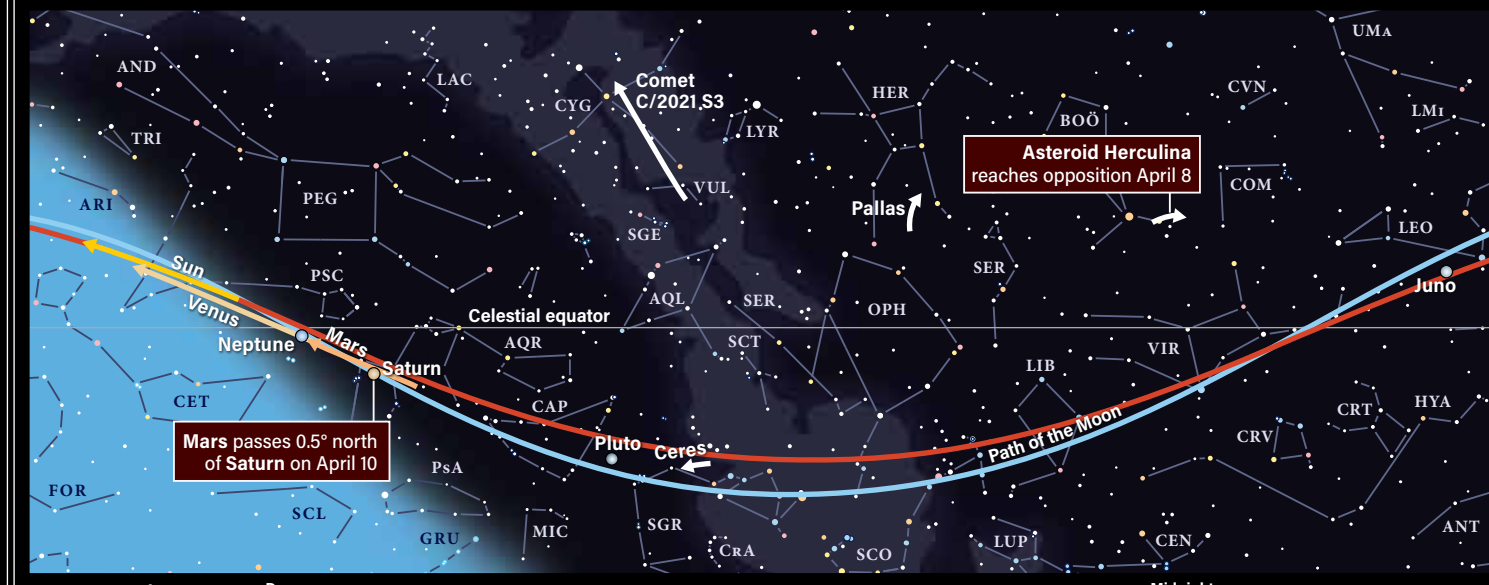
23 Full Moon occurs at 7:49 P.M. EDT

24 Mercury is stationary, 4 A.M. EDT

26 The Moon passes 0.3° north of Antares, 5 P.M. EDT

28 Mars passes 0.04° south of Neptune, midnight EDT

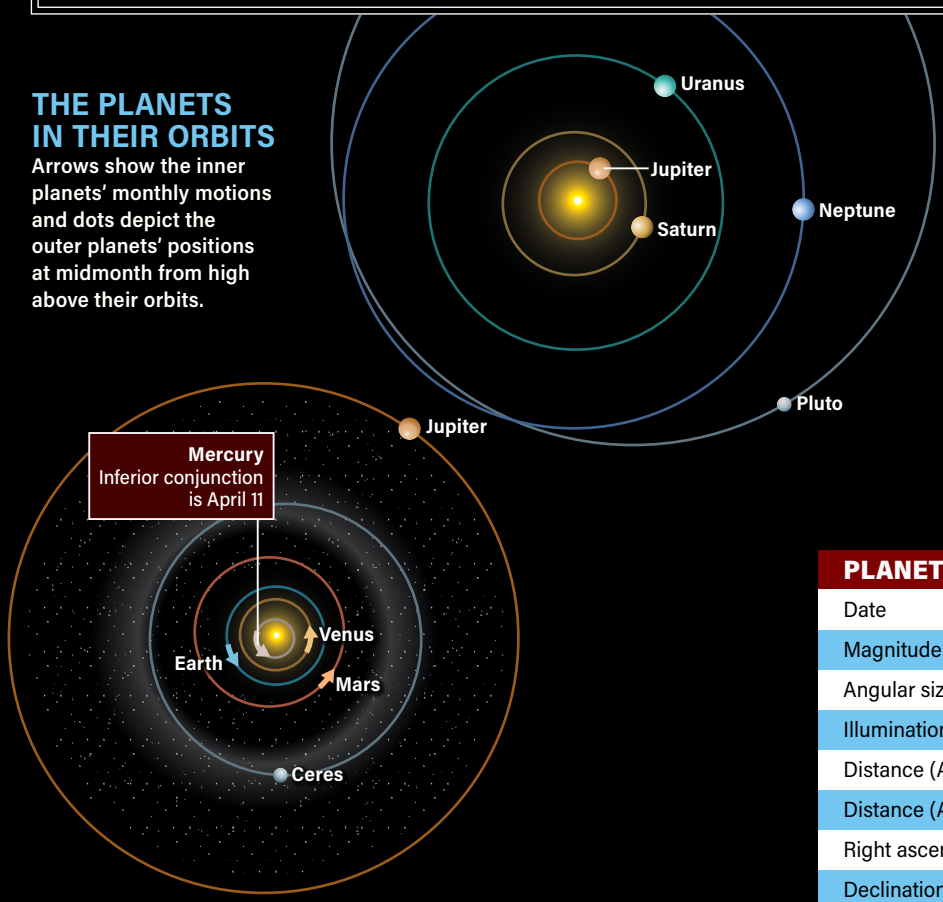
PATHS OF THE PLANETS



To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved blue line.

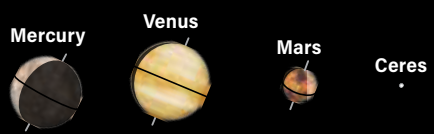
THE PLANETS IN THEIR ORBITS

Arrows show the inner planets' monthly motions and dots depict the outer planets' positions at midmonth from high above their orbits.



THE PLANETS IN THE SKY

These illustrations show the size, phase, and orientation of each planet and the two brightest dwarf planets at 0h UT for the dates in the data table at bottom. South is at the top to match the view through a telescope.



PLANETS	MERCURY	VENUS
Date	April 1	April 1
Magnitude	1.3	–3.9
Angular size	9.3"	10.3"
Illumination	17%	96%
Distance (AU) from Earth	0.726	1.623
Distance (AU) from Sun	0.359	0.728
Right ascension (2000.0)	1h34.8m	23h42.2m
Declination (2000.0)	13°22'	–3°31'

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and colored dots show motions and locations of solar system objects during the month.

APRIL 2024

Callisto

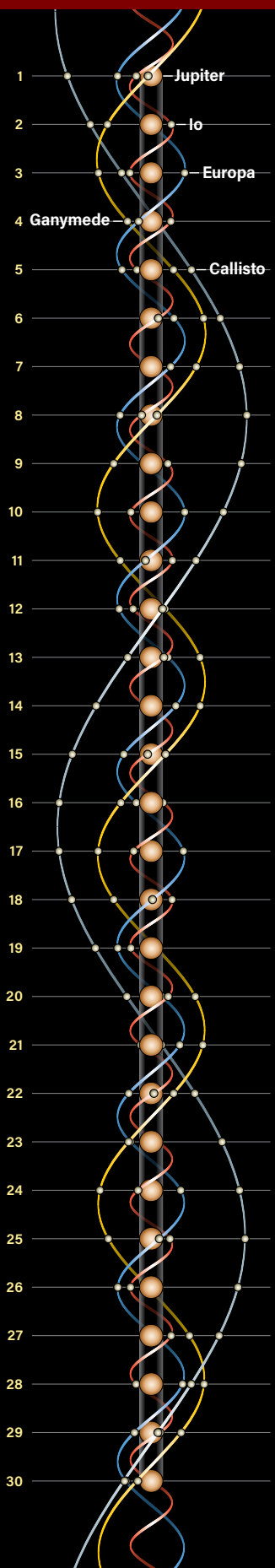
Europa

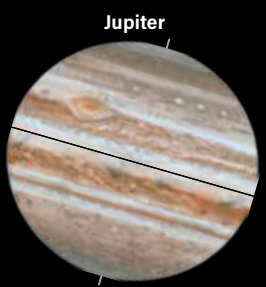
Io

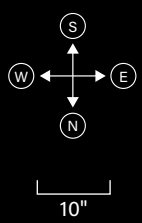
Ganymede

JUPITER'S MOONS

Dots display positions of Galilean satellites at 10 P.M. EDT on the date shown. South is at the top to match the view through a telescope.







Uranus Neptune Pluto

MARS	CERES	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
April 15	April 15	April 15	April 15	April 15	April 15	April 15
1.2	8.7	–2.0	1.0	5.9	7.8	15.3
4.6"	0.5"	33.4"	15.9"	3.4"	2.2"	0.1"
95%	97%	100%	100%	100%	100%	100%
2.037	2.548	5.899	10.450	20.493	30.790	35.093
1.385	2.843	5.008	9.708	19.597	29.901	34.994
23h16.2m	19h21.6m	3h11.5m	23h06.6m	3h15.2m	23h54.9m	20h18.6m
–6°04'	–23°46'	17°01'	–7°34'	17°47'	–1°53'	–22°41'

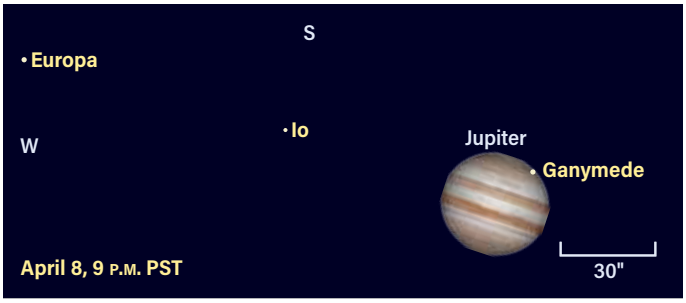
 — Continued from page 29

WHEN TO VIEW THE PLANETS

EVENING SKY
Mercury (west)
Jupiter (west)
Uranus (west)

MORNING SKY
Mercury (east)
Venus (east)
Mars (east)
Saturn (east)
Neptune (east)

West Coast wins



Ganymede skims Jupiter's southern polar region on the 8th. The transit is only visible from the U.S. Pacific time zone, beginning when the planet is already low in the sky. Callisto lies far east of Jupiter at this time.

back to the corona, because that's what you traveled to see.

Mercury is fading in brighter evening twilight after last month's eastern elongation. Catch it in the first couple of days of April. It shines at magnitude 1.3 on April 1 and magnitude 1.6 on April 2. It stands 5° high 45 minutes after sunset on April 1, and 1° lower on the 2nd. Over the next few days, the already tough target fades and sinks too low to pick up. Anyone living at higher altitude with little or no horizon haze might follow it through April 3.

Mercury reaches inferior conjunction with the Sun on April 11 and then quickly springs into the morning sky. It rises about 30 minutes before the Sun on April 20, but is too faint to see. By April 30, it is 3° high half an hour before sunrise and has brightened to magnitude 1.1.

Jupiter stands about 20° above the western horizon 45 minutes after sunset in early April, offering a narrow window for observation. This altitude drops to 2° at the same time by the end of the month, so the window is closing fast. It's best in the first week of April; after that it's more challenging, depending on your local obstructions.

However, there's a fine conjunction to watch for as Jupiter finally passes Uranus on the 20th. An added attraction is the appearance of Comet 12P/Pons-Brooks in the same area of sky, although it may be too faint to see in binoculars due to the twilight. Pons-Brooks, discovered in 1812, reaches perihelion April 21.

The evening drama begins April 10, when a slender crescent Moon stands in the deepening twilight not far from the Pleiades (M45). Jupiter lies 4° below the Moon and glows brilliantly at magnitude –2. Grab binoculars to spy **Uranus** in the same field of view, located 1.8° above Jupiter and shining at magnitude 5.9.

Comet Pons-Brooks lies 4° due west of Jupiter — scan the area with binoculars starting about 50 minutes after sunset. You'll have about 45 minutes more to spot the comet before its declining altitude in a darker sky competes with increasing horizon haze. If we're extraordinarily lucky, the comet will produce another outburst and become a

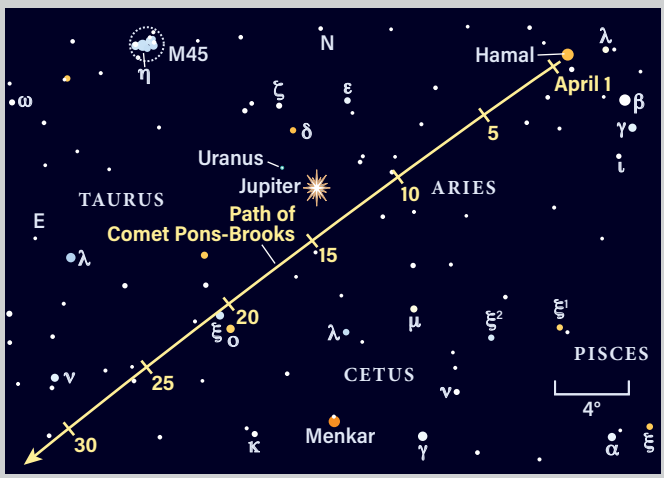
Faster-moving Jupiter passes Uranus on the ecliptic, standing due south of the ice giant early on April 20.

COMET SEARCH | Spring serenity or surprise?

SAVE THE EVENING of the 10th for cometary charm. Start observing 50 minutes after sunset to experience the full range of twilight colors, contrasts on the crescent Moon, blazing Jupiter and dim Uranus, and the dusty sword of 12P/Pons-Brooks, with the sparkling Pleiades (M45) floating above the whole scene.

Maximize your encounter by moving west of any big city to avoid looking through its veil of light pollution. Predicted to be 4th magnitude, Pons-Brooks is unlikely to be the lightsaber-like spectacle carried by newsfeeds. Yet the straight ion tail, carried by charged solar particles, might be long enough to thread the gap between the Moon and Jupiter. Binoculars are best, but a very low-power wide-field scope will also deliver. Remember to boost the power to check out the core; you just might see some green.

Comet 12P/Pons-Brooks

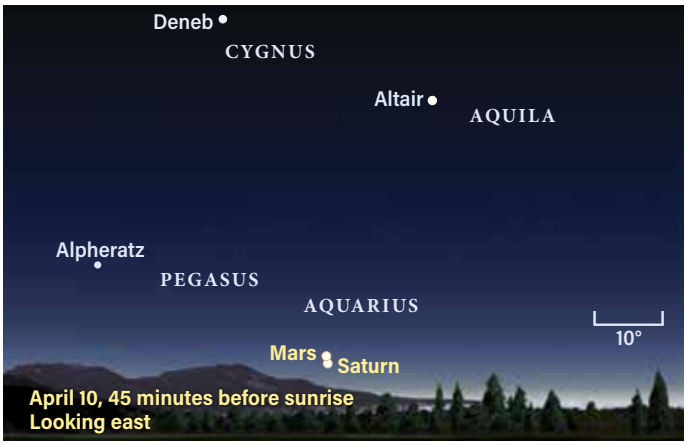


Comet Pons-Brooks slides through Aries and Taurus and may make an appearance during the eclipse. The positions of the planets are shown here on April 8. Note that after about midmonth, Pons-Brooks becomes much harder to observe from the Northern Hemisphere.

The comet has already had at least three outbursts at the time of this writing, so take a quick look every evening — and during the total solar eclipse, when it still sits near Jupiter — in case it erupts anew. Hit the observing hard in the first two weeks of the month. Afterwards, Pons-Brooks gets swallowed by twilight. South of the equator it remains a nice sight.

Need more comets? C/2021 S3 (PanSTARRS) glows at 7th magnitude, sailing the heart of the Cygnus Star Cloud overnight, only 2.5° from Albireo on the 6th. It should be turning green for imagers.

Red Planet passing through



Mars and Saturn come close in the morning sky on April 10. Before this date, Mars is southwest of Saturn. After it, Mars lies to Saturn's northeast.

naked-eye object from dark locations. Whatever happens, the scene will present a fine photographic composition.

Pons-Brooks heads southeast and stands 4.5° due south of Jupiter by April 16 and crosses into western Taurus on the 19th. The comet is very close to the 4th-magnitude star Xi (ξ) Tauri on the 20th, though it's becoming a difficult object in twilight.

The four bright Galilean moons, Io, Europa, Ganymede, and Callisto, orbit Jupiter with periods ranging from nearly two to 17 days. Despite the limited observing window this month, one event involving Ganymede is a good target for the Pacific time zone of the U.S.

Ganymede transits the planet's south polar region April 8 beginning about 8:51 P.M. PST. Jupiter is less than 15° high, so you'll need a clear western view to catch the beginning of the transit. Jupiter sets while the transit is underway.

The main planetary action is in the morning as **Mars** and **Saturn** grow in visibility, visited by a crescent Moon early on.

Forty minutes before sunrise on April 1, Mars and Saturn sit 6° and 3° above the eastern horizon, respectively. They're 6° apart. Saturn is fractionally brighter at magnitude 1, with Mars 0.2 magnitude fainter.

By April 5, the two planets are only 3.5° apart. A waning crescent Moon joins the pair, 10.5° southwest of Mars. High above stands the Summer Triangle. On April 6, the thinner crescent 27-day-old Moon lies 2° southeast of Saturn.

The ringed planet and the Red Planet continue to close in, with the actual conjunction occurring late on the 10th. Earlier that morning, U.S. observers will see Mars 30' northwest of Saturn. The pair stands 5° high 45 minutes before sunrise.

The following morning, April 11, Mars stands 35' northnortheast of Saturn. Catch the planets soon after they rise (around 5:15 A.M. local time). Starting around 6 A.M., you should have a nice view if your eastern horizon is clear.

Through a telescope Saturn dominates the scene, with a 16"-wide planetary disk and rings extending about 36" from end to end. The rings' tilt is a slight 4°, with much of the southern half of the planet now visible. Mars shows a tiny disk 5" across.

The visibility of Mars doesn't improve much as the month progresses. By April 30 the planet stands 6° high in the eastern sky an hour before sunrise. On that date, Saturn is 13° southwest of Mars and already 11° high at the same time.

Neptune passed solar conjunction with the Sun last month and remains difficult due to morning twilight. By the end of the month it is 6° high in the east an hour before sunrise and 1° west of Mars.

Venus is approaching superior conjunction with the Sun in early June. With a clear eastern horizon you might spot it soon after it rises some 30 minutes before the Sun early in the month, shining at magnitude –3.9.

Martin Ratcliffe *is a planetarium professional with Evans & Sutherland and enjoys observing from Salt Lake City.* **Alister Ling**, *who lives in Edmonton, Alberta, is a longtime watcher of the skies.*

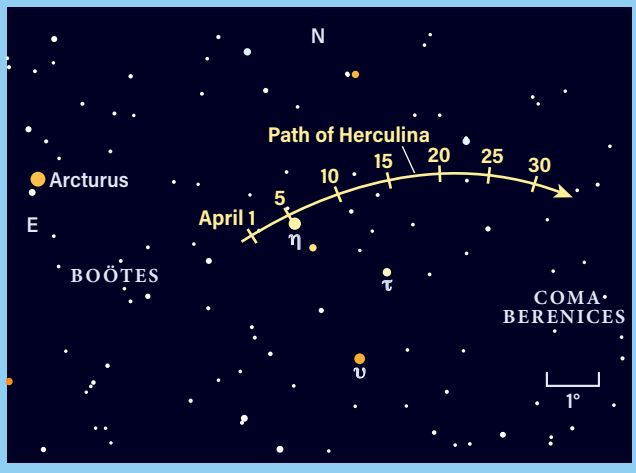
GET DAILY UPDATES ON YOUR NIGHT SKY AT **www.Astronomy.com/skythisweek.**

LOCATING ASTEROIDS
Arc to Arcturus and hop to Herculina

A 60MM SCOPE from the suburbs is all you'll need to pick up 532 Herculina at 9th magnitude. Simply start at Arcturus, fourth-brightest star in the sky, then center on magnitude 2.7 Eta (η) Boötis, to Arcturus' west-southwest. During the first week of the month Herculina will be in the same field! Grant yourself a four-hour session on the 5th and you will see the space rock shift against two brighter stars to turn a crooked line straight.

From the 15th through the 17th, this main-belt asteroid is the brightest object in the field. Somewhat potato-shaped and spanning about 100 miles, Herculina was discovered photographically by Max Wolf in 1904. It escaped earlier detection thanks to its large orbital inclination of 16°, which carries it well above and below the classic asteroid hunting ground near the ecliptic. In fact, Herculina is so high above the ecliptic this month that the Moon's glare won't bother us when it passes by. Herculina tips the scales as the 11th-most massive world in the main belt.

Bright signpost



Herculina arcs near blazing Arcturus in Boötes this month. The main-belt world also passes close to Eta Boötis on the 5th.

Astronomy's atlas

After six years, seven months, and 18 days, a total eclipse of the Sun will once again cross North America.

The total solar eclipse of April 8, 2024, will dazzle tens of millions of people from Mazatlán, Mexico, to the shores of Newfoundland, Canada, just north of St. John's. The U.S. states touched by totality are Texas, Oklahoma, Arkansas, Missouri, Tennessee, Illinois, Kentucky, Indiana, Ohio, Michigan, Pennsylvania, New York, Vermont, New Hampshire, and Maine.

Inside the path of totality, the sky will suddenly darken to a deep twilight and the Sun's magnificent corona will appear around the pitch-black disk of the eclipsing Moon. Totality is easily one of the most beautiful natural sights, and people will come from all over the globe to see the corona's majesty.

Nearly all of North America except for Alaska will have the opportunity to view and enjoy at least a partial solar eclipse. (Don't feel sorry for Alaska, though — it will be the only place in the U.S. to see the total solar eclipse of March 30, 2033.)

The impact of totality

The 2024 total solar eclipse will have an even greater impact than the 2017 eclipse across America. The reasons are population, proximity, duration, and public memory.

- Within the U.S., more than 31 million people live inside the path of totality, as compared to 12 million people inside the path in 2017. Millions more reside within the path in Mexico and Canada, especially the more populated cities of Mazatlán, Torreón, Montreal, Toronto, and Ottawa.
- The path of totality comes within 200 miles (322 kilometers) of major cities of the U.S. Eastern Seaboard: Washington, D.C.; Baltimore; Philadelphia; New York; and Boston. Additionally, over half the nation's population lives within 250 miles (400 km) of the path of totality.
- The duration of the 2024 eclipse is nearly twice that of the 2017 eclipse. This will attract additional visitors.
- The U.S. national memory of a total solar eclipse is relatively fresh from 2017. Before the 2017 eclipse, the last total solar eclipse on the U.S. mainland was in 1979, a gap of 38 years. Those who remember missing out on the great spectacle just six years ago will most likely make plans to attend this month's eclipse.

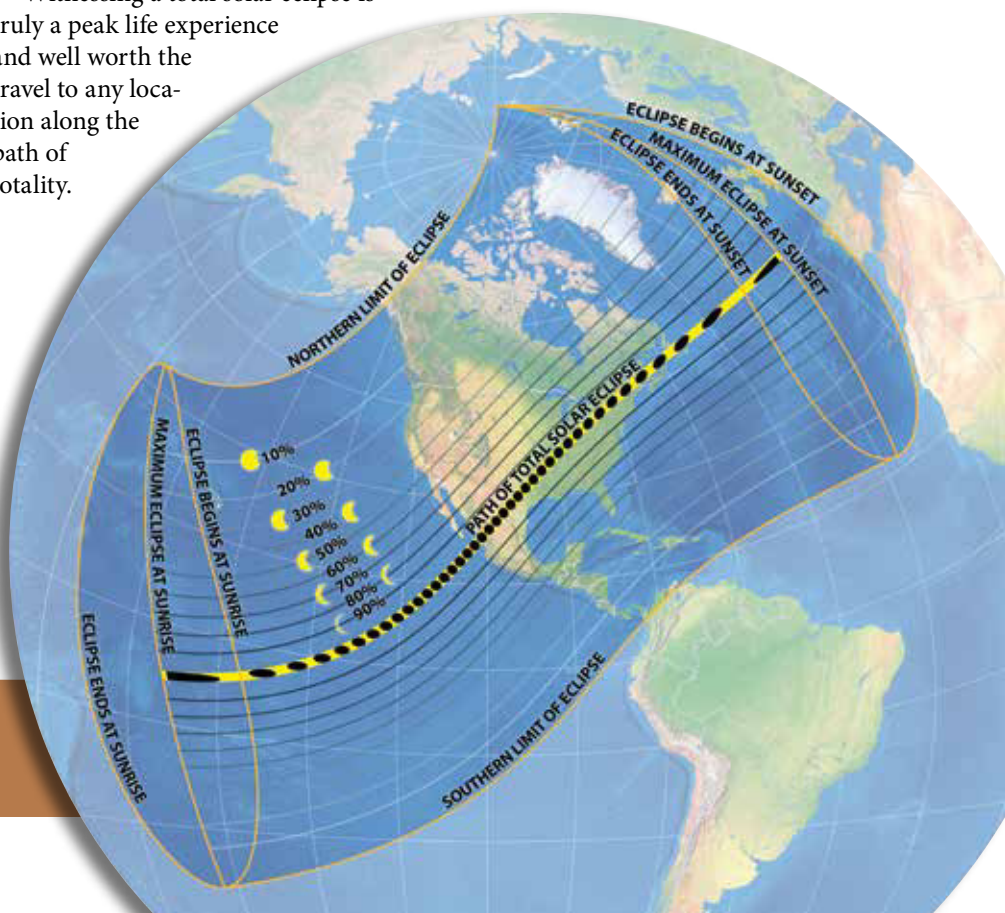
Witnessing a total solar eclipse is truly a peak life experience and well worth the travel to any location along the path of totality.

Reading the maps

The following 12 pages of eclipse maps will guide you to the best location to observe this April's total solar eclipse. The maps address three questions frequently asked by eclipse travelers: Where are the best places to see the total solar eclipse? How long will totality be at my location? And what time will totality begin?

In general, you want to be as close to the center of the path of totality as possible to see the longest duration of totality.

On each map, the dark gray diagonal belt is the path of totality where the Moon's shadow will travel from west to east. The ovals along the path show the Moon's shadow at five-minute intervals. The shape of the shadow incorporates the precise shape of the Moon's limb at the time of totality. Cities inside the path of totality are marked by white color-coded font. The highway system is light



This map shows the extent of the Moon's outer shadow (penumbra) and inner shadow (umbra), where totality is seen. The black ovals depict the Moon's shadow at five-minute intervals. MICHAEL ZEILER

# of totality

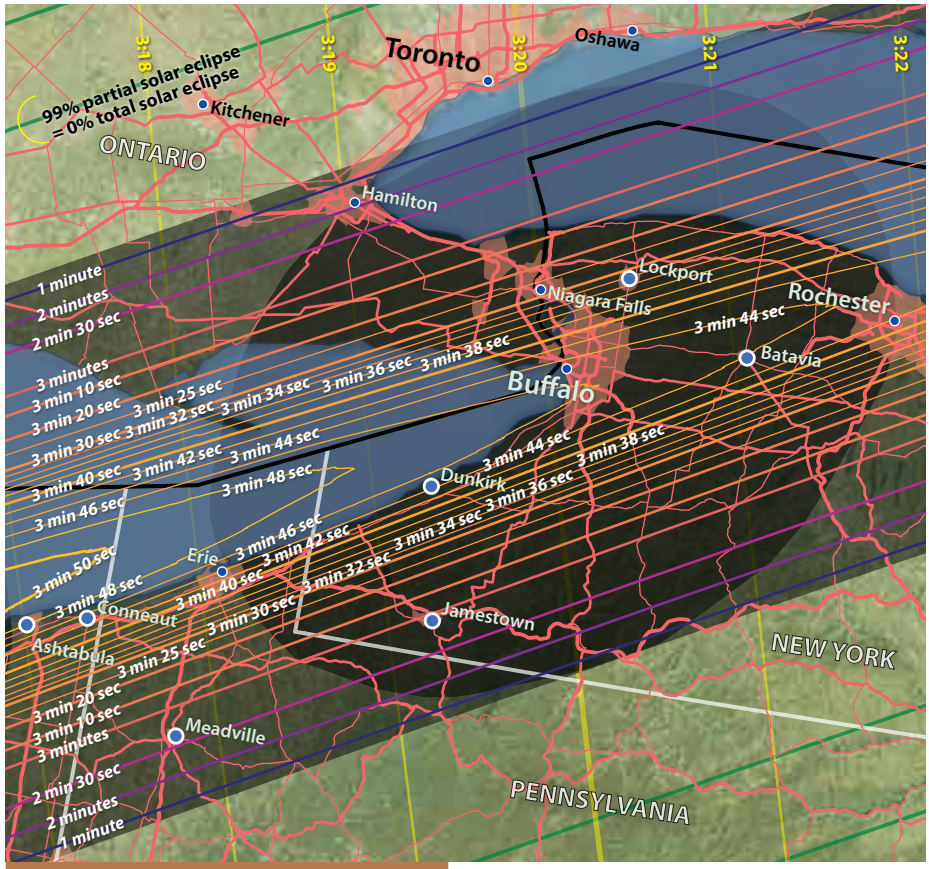
Use these detailed maps to track the eclipse from Mexico to Canada. BY MICHAEL ZEILER

red; the thickest lines are interstate highways.

The yellow lines perpendicular to the path of totality, with times also indicated in black, show the local time of maximum eclipse. Outside the path of totality, this is the time of maximum partial eclipse. Inside the path of totality, the time colored in white indicates the midpoint of totality (maximum eclipse).

You can estimate how long totality will last at your location by reading the curves of totality duration within the path, from the central yellow oval to the outer dark purple lines. For example, Hamilton, Ontario, gets just under 2 minutes of totality and Erie, Pennsylvania, receives 3 minutes 44 seconds.

Along the sides of the maps, the crescent Sun figures with percent values indicate the Sun's appearance at maximum eclipse. The values given are eclipse obscurations, the fraction of the Sun's disk occulted by the Moon.



Buffalo, New York, will experience just over 3 minutes 44 seconds of totality. There, maximum eclipse occurs just after 3:20 P.M. EDT. Because the time of maximum eclipse marks the halfway point of totality, subtract half the duration to estimate what time totality begins. Thus, totality in Buffalo begins at about 3:18 P.M. EDT. MICHAEL ZEILER

Stack your odds on eclipse day

Eclipse chasers are obsessive about weather because it is the primary factor for success on eclipse day. Here are tips to use alongside these maps to ensure you view the best total solar eclipse.

• Choose a base location with favorable weather prospects and a good highway system for relocation if needed. You can also consult "Your eclipse weather forecast" on page 20 of this issue or https://eclipsophile.com, both created by meteorologist Jay Anderson, for a thorough review of the climatology along the path of totality in April.

• Starting about a week before the eclipse, weather models will give a general indication of conditions at your location on eclipse day. Each day, keep an eye on how the models evolve and make your contingency plan for eclipse day. From your base, pick one spot inside the path of totality to the southwest and another to the northeast, and see which site's weather is more promising. You can access the latest weather models and satellite imagery at https://eclipsophile.com.

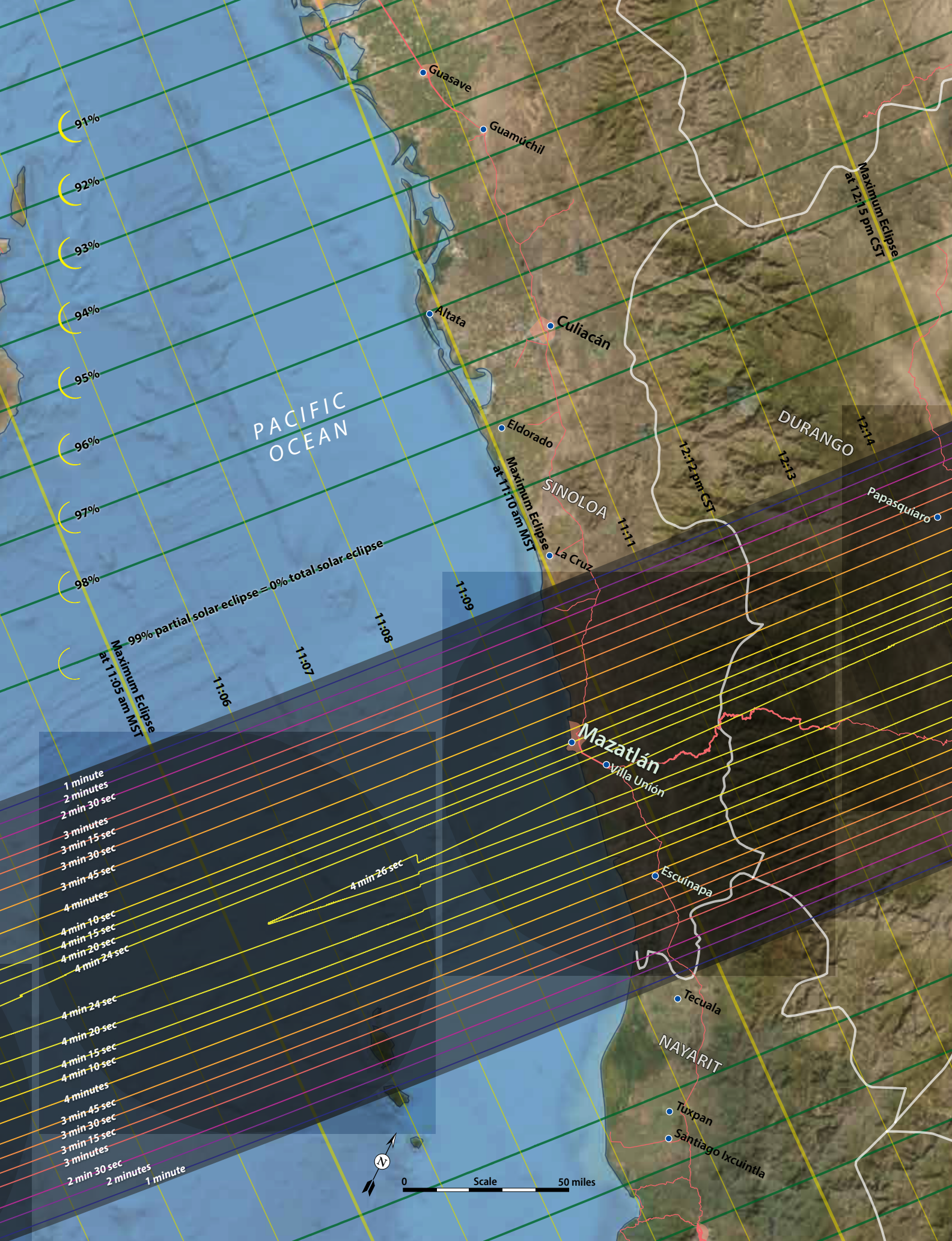
• Study satellite weather imagery beginning the evening before the eclipse. If you need to relocate to a back-up location, either leave that night or in the predawn hours of eclipse day.

• Keep a full gas tank or electric charge and have plenty of essential supplies on hand. Meals in restaurants may or may not be available (or quick), so carry food and drinks. Don't forget your eclipse viewers as well as other fun items to cast partial eclipse shadows, such as a kitchen colander.

• After the eclipse, be prepared for traffic jams and long drive times. Phone maps with a traffic layer may help guide you around the worst traffic.

I've never met a single person who has traveled near or far to observe a total solar eclipse and regretted the effort to do so. Totality is an outstanding spectacle that makes this level of preparation and action more than worthwhile. Use these maps and the tips you'll find throughout this issue to plan your perfect eclipse!

Michael Zeiler *is a cartographer, eclipse chaser, and developer of* GreatAmericanEclipse.com. *He is co-author of* Atlas of Solar Eclipses: 2020 to 2045.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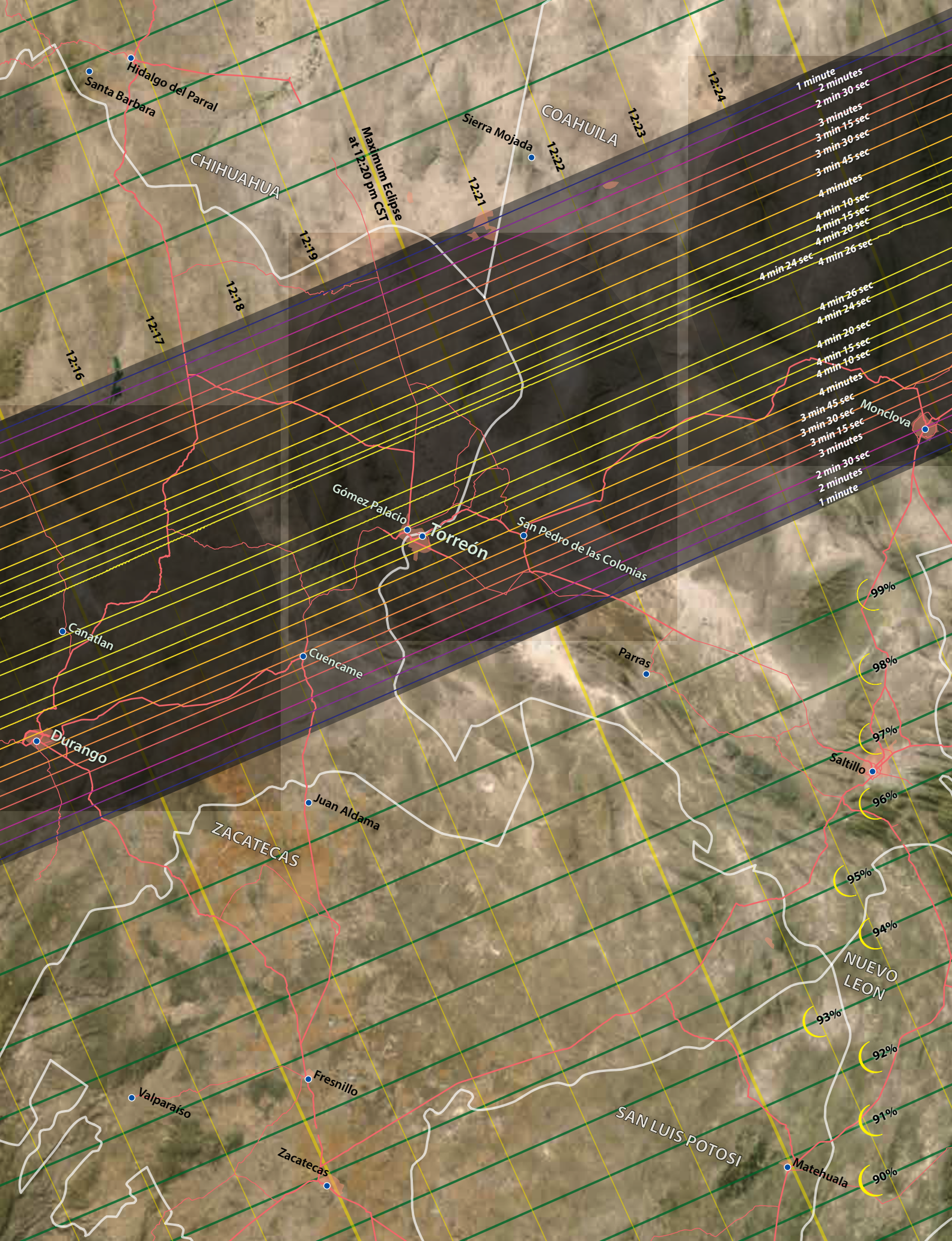
Guamúchil
Altata
Culiacán
Eldorado
La Cruz
Mazatlán
Villa Unión
Escuinapa
Tecuala
Tuxpan
Santiago Ixcuintla
Papasquiaro
PACIFIC OCEAN
SINOLOA
DURANGO
NAYARIT
91%
92%
93%
94%
95%
96%
97%
98%
99% partial solar eclipse = 0% total solar eclipse
Maximum Eclipse at 11:05 am MST
Maximum Eclipse at 11:10 am MST
Maximum Eclipse at 12:15 pm CST
12:12 pm CST
11:06
11:07
11:08
11:09
11:11
12:13
12:14
1 minute
2 minutes
2 min 30 sec
3 minutes
3 min 15 sec
3 min 30 sec
3 min 45 sec
4 minutes
4 min 10 sec
4 min 15 sec
4 min 20 sec
4 min 24 sec
4 min 26 sec
N
0
Scale
50 miles


Hidalgo del Parral
Santa Barbara
CHIHUAHUA
Maximum Eclipse at 12:20 pm CST
Sierra Mojada
COAHUILA
12:24
12:23
12:22
12:21
12:19
12:18
12:17
12:16
1 minute
2 minutes
2 min 30 sec
3 minutes
3 min 15 sec
3 min 30 sec
3 min 45 sec
4 minutes
4 min 10 sec
4 min 15 sec
4 min 20 sec
4 min 24 sec
4 min 26 sec
Monclova
Gómez Palacio
Torreón
San Pedro de las Colonias
Canatlan
Cuencame
Parras
Durango
Saltillo
Juan Aldama
ZACATECAS
99%
98%
97%
96%
95%
94%
NUEVO LEON
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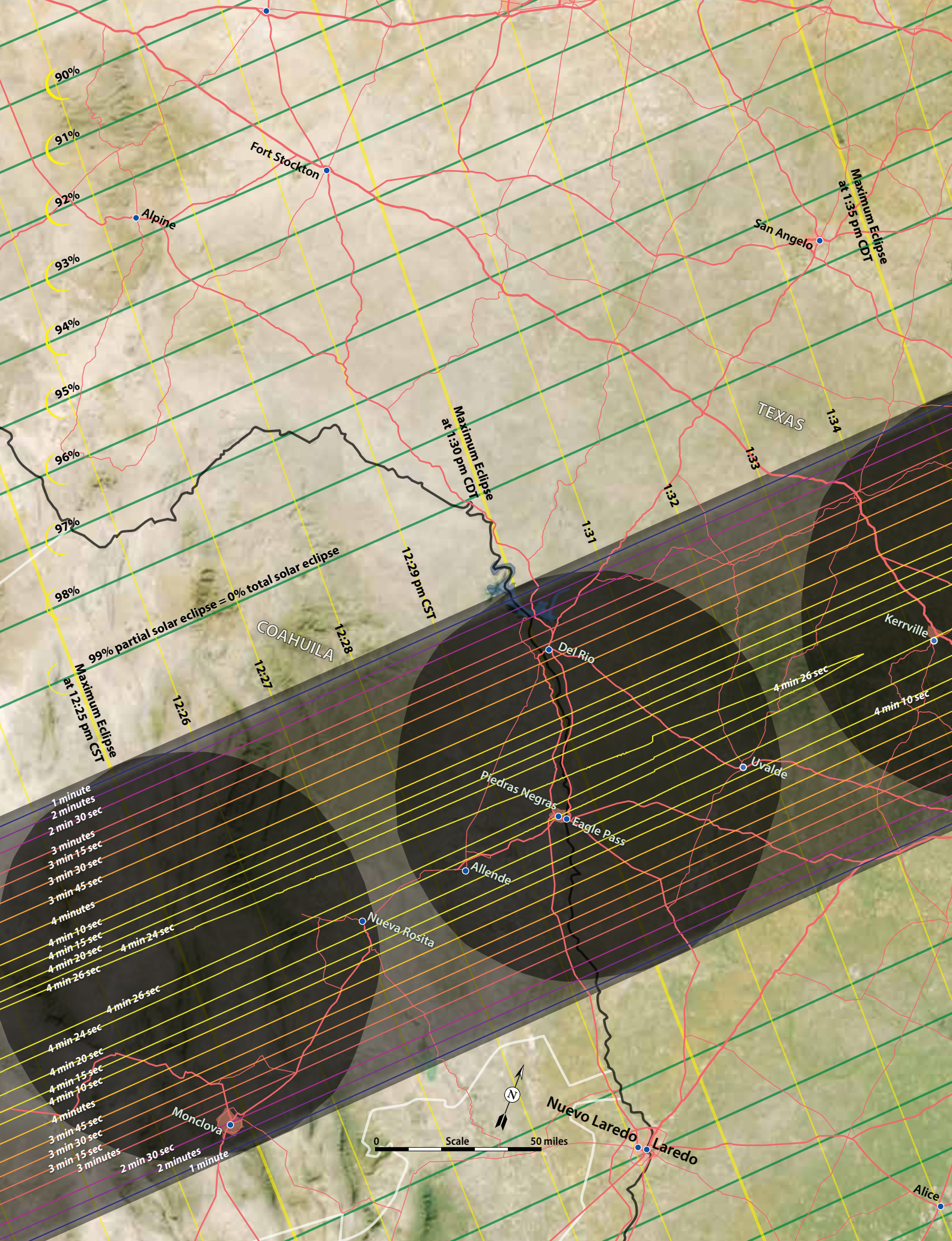
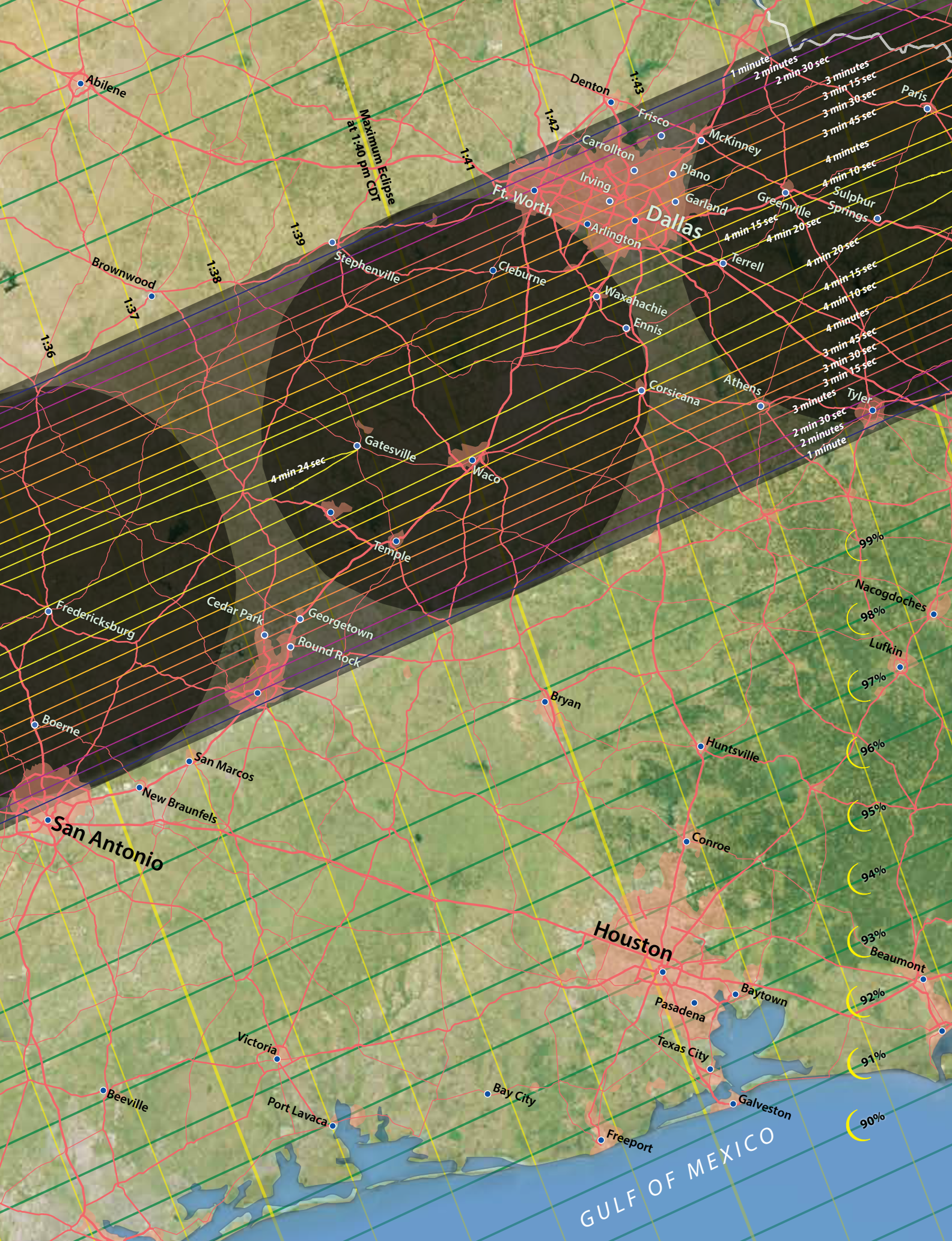
92%
91%
90%
Fresnillo
Valparaíso
Zacatecas
SAN LUIS POTOSI
Matehuala


90%
91%
92%
93%
94%
95%
96%
97%
98%
99% partial solar eclipse = 0% total solar eclipse
Fort Stockton
Alpine
San Angelo
Maximum Eclipse at 1:35 pm CDT
Maximum Eclipse at 1:30 pm CDT
Maximum Eclipse at 12:25 pm CST
TEXAS
COAHUILA
1:34
1:33
1:32
1:31
12:29 pm CST
12:28
12:27
12:26
Del Rio
Kerrville
Uvalde
Piedras Negras
Eagle Pass
Allende
Nueva Rosita
Monclova
Nuevo Laredo
Laredo
Alice
4 min 26 sec
4 min 10 sec
1 minute
2 minutes
2 min 30 sec
3 minutes
3 min 15 sec
3 min 30 sec
3 min 45 sec
4 minutes
4 min 10 sec
4 min 15 sec
4 min 20 sec
4 min 24 sec
4 min 26 sec
N
0
Scale
50 miles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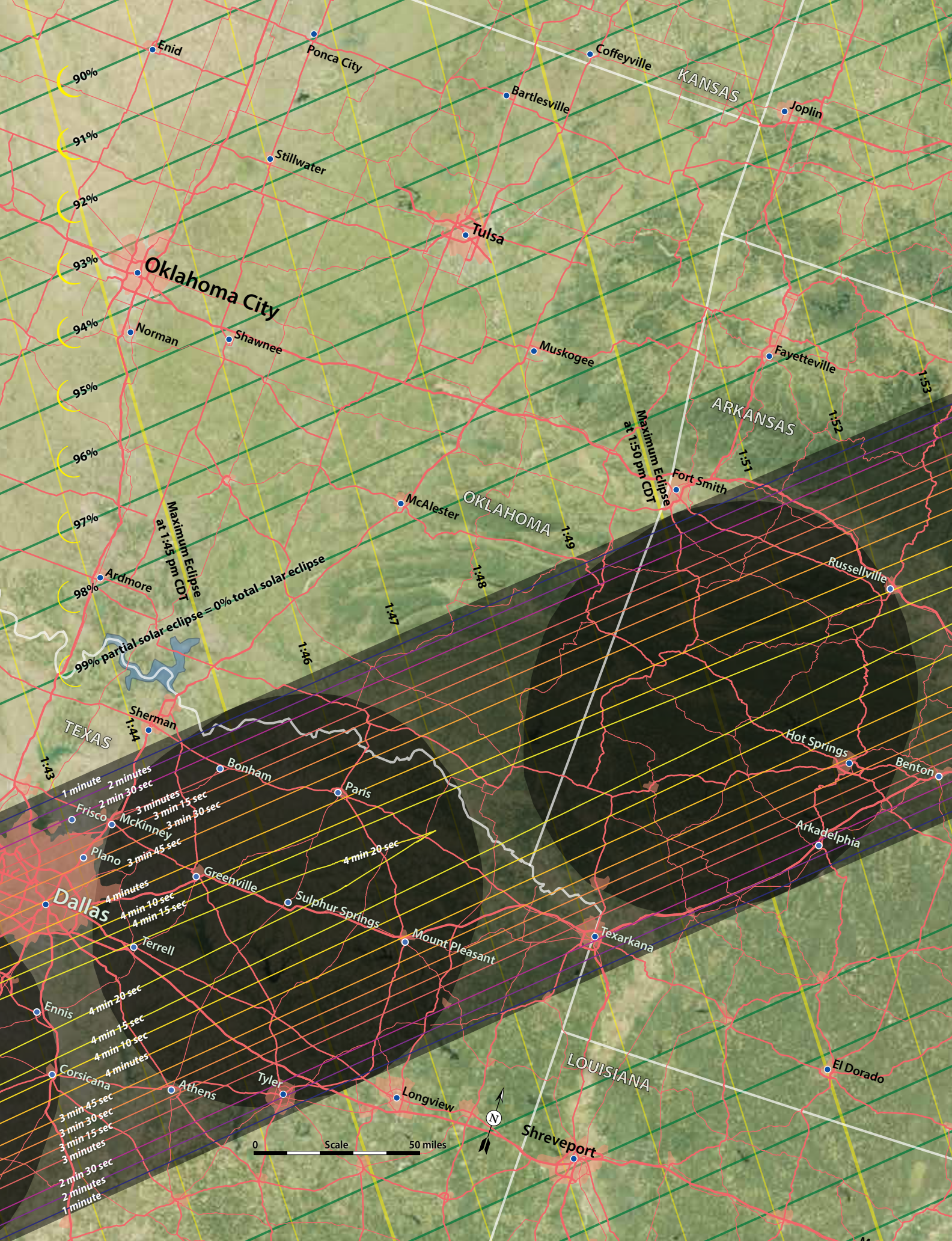
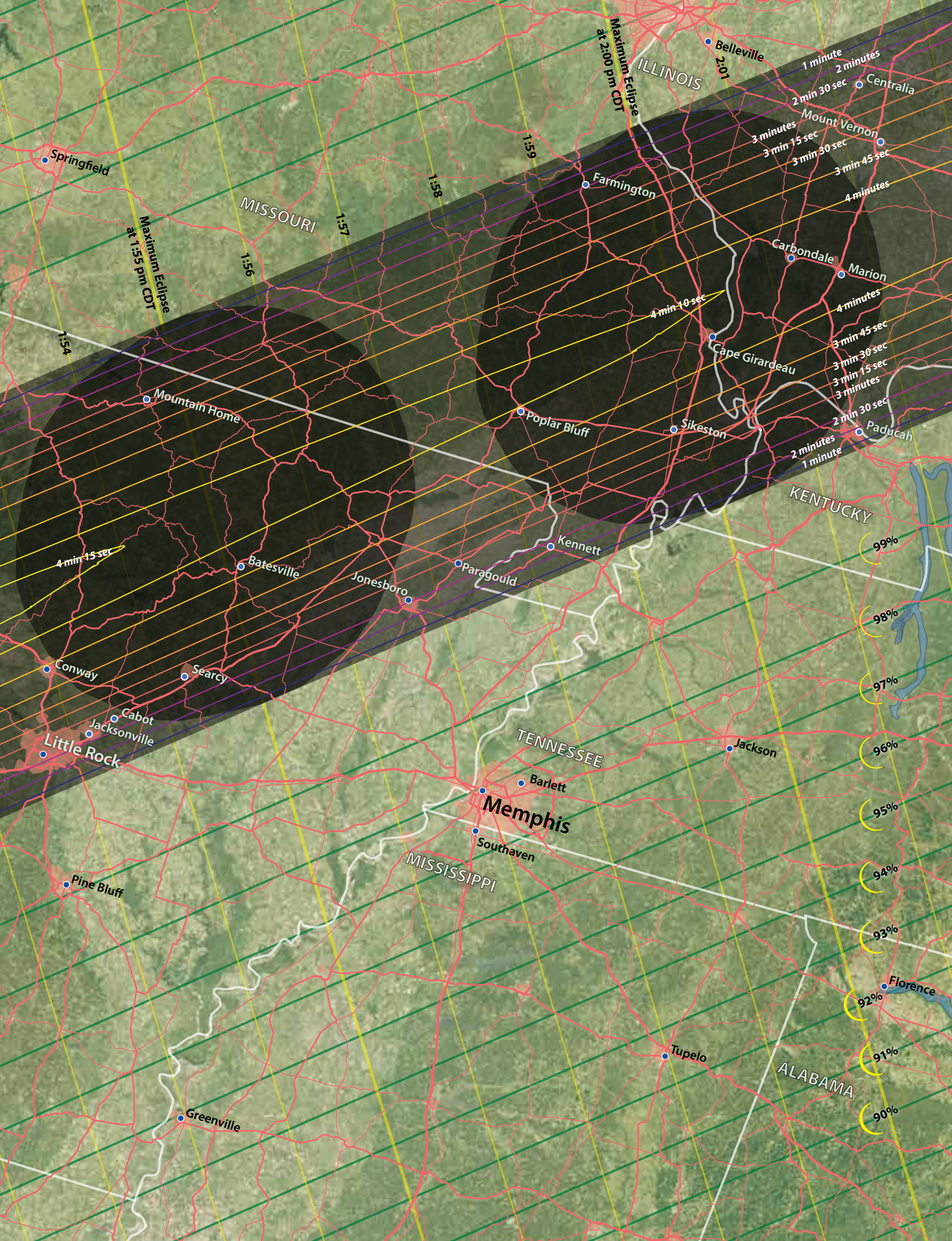
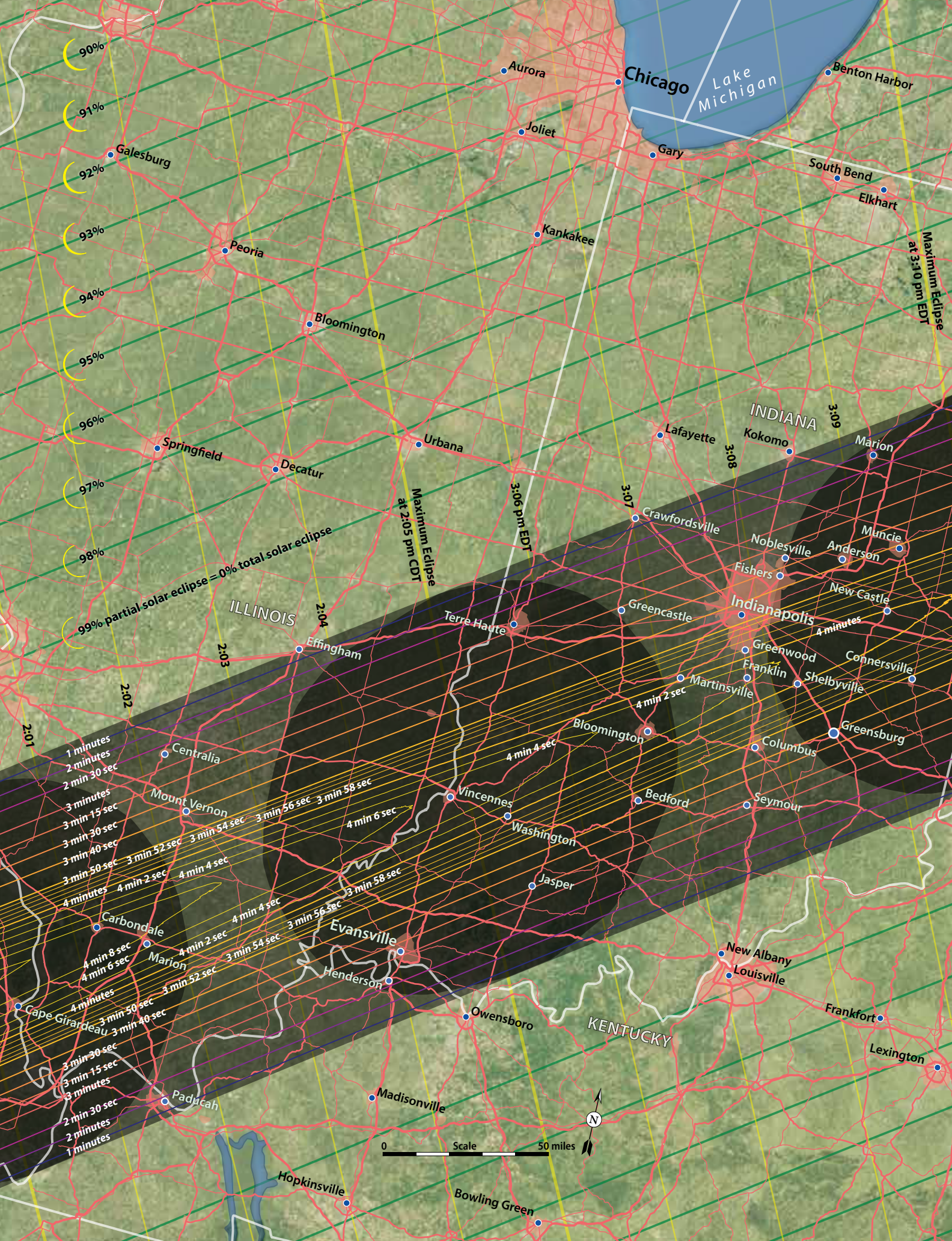
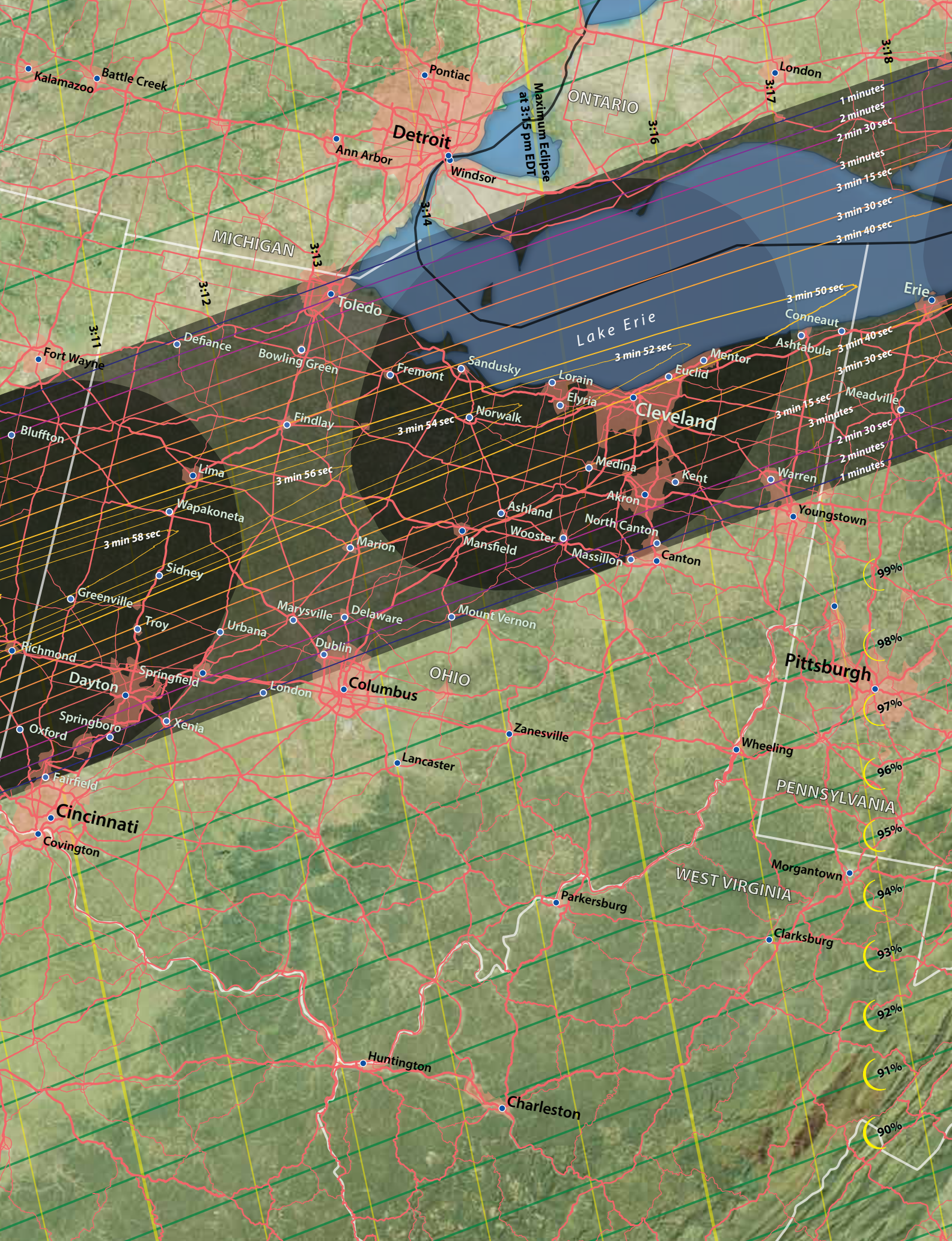
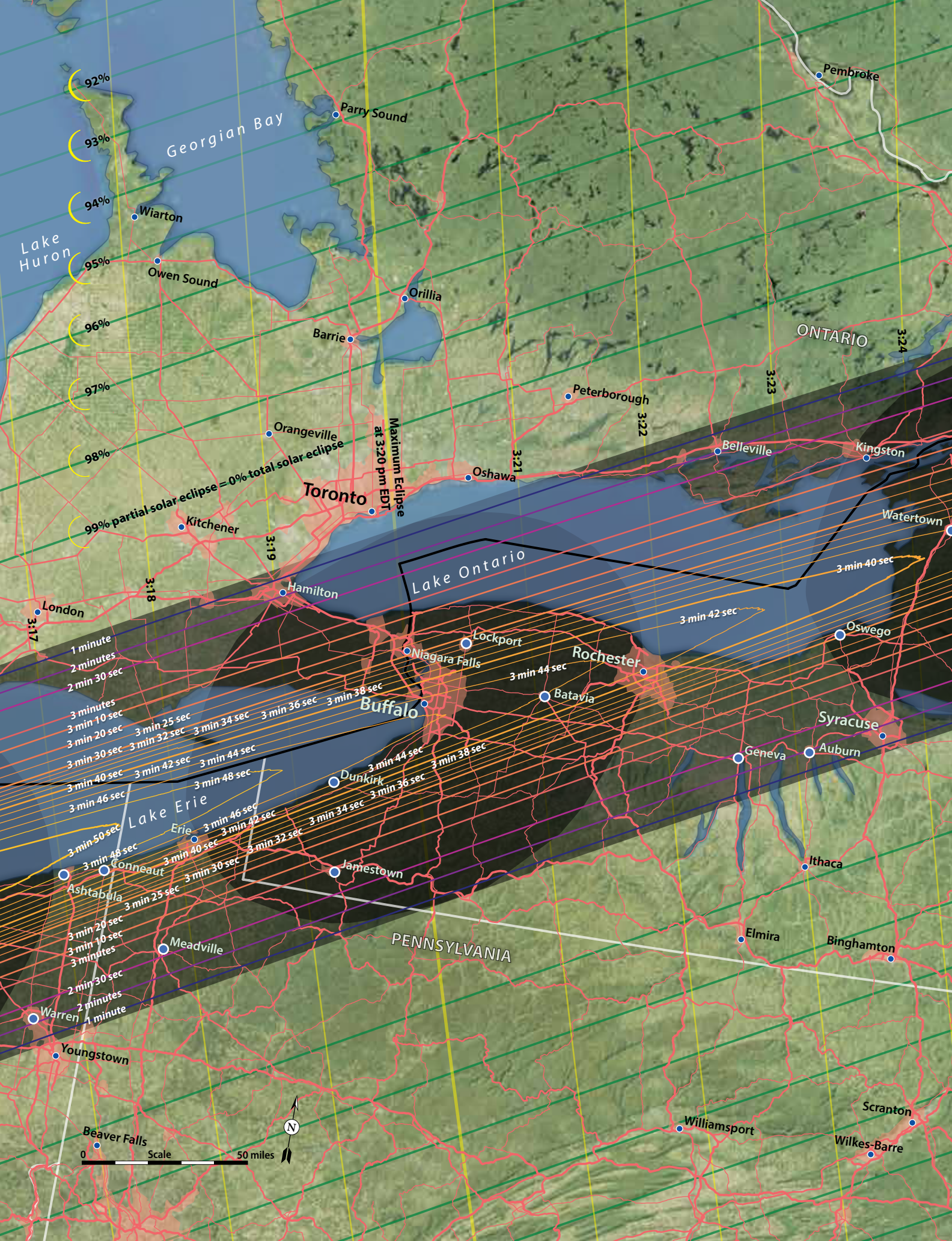
Brownwood
Stephenville
Cleburne
Denton
Frisco
Carrollton
Irving
Ft. Worth
Arlington
Dallas
McKinney
Plano
Garland
Greenville
Paris
Sulphur Springs
Terrell
Waxahachie
Ennis
Corsicana
Athens
Tyler
Gatesville
Waco
Temple
Fredericksburg
Cedar Park
Georgetown
Round Rock
Boerne
San Marcos
New Braunfels
San Antonio
Bryan
Huntsville
Conroe
Houston
Nacogdoches
Lufkin
Beaumont
Baytown
Pasadena
Texas City
Galveston
Freeport
Bay City
Victoria
Port Lavaca
Beeville
GULF OF MEXICO
Maximum Eclipse at 1:40 pm CDT
1:43
1:42
1:41
1:39
1:38
1:37
1:36
1 minute
2 minutes
2 min 30 sec
3 minutes
3 min 15 sec
3 min 30 sec
3 min 45 sec
4 minutes
4 min 10 sec
4 min 15 sec
4 min 20 sec
4 min 24 sec
99%
98%
97%
96%
95%
94%
93%
92%
91%
90%

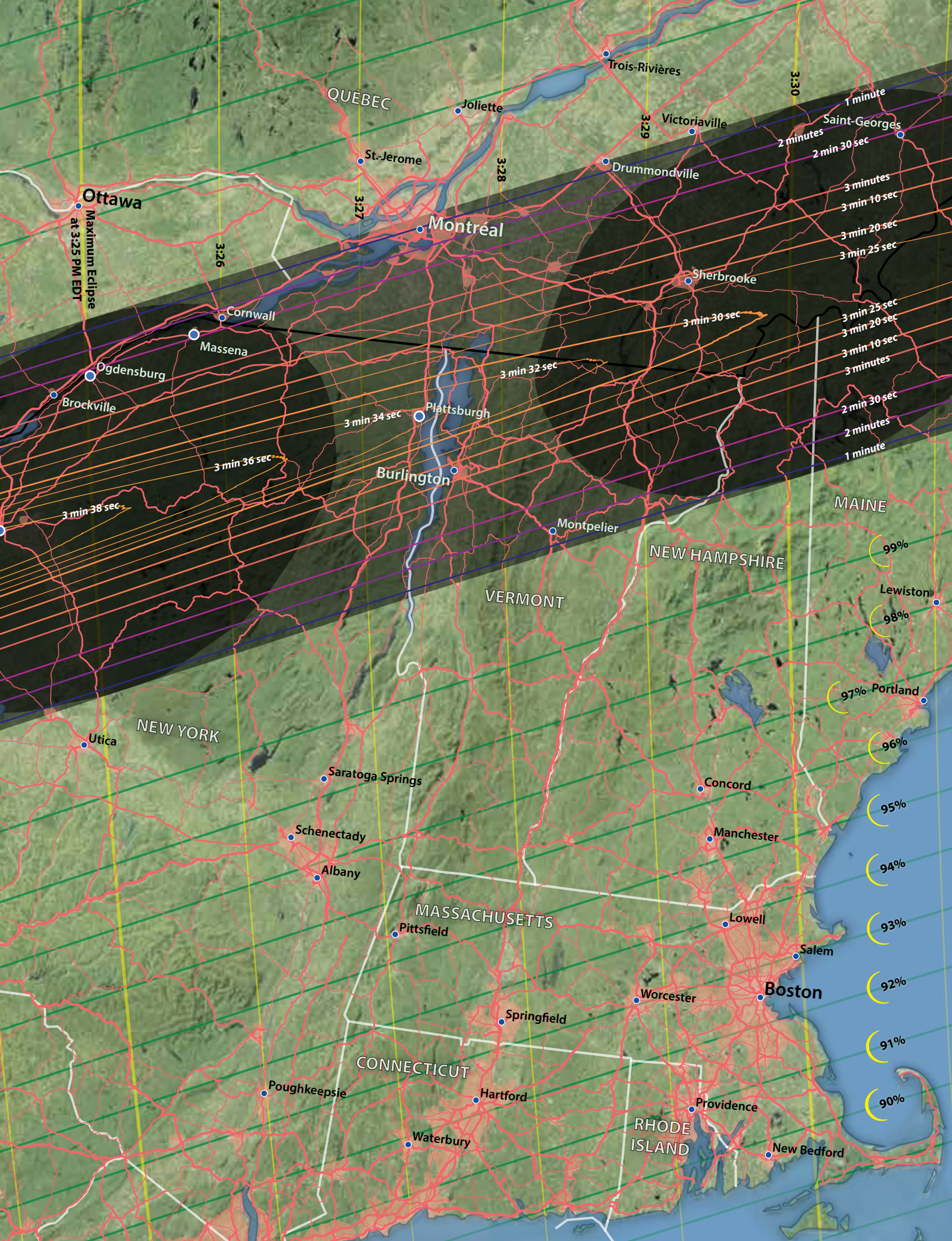

Enid
Ponca City
Coffeyville
KANSAS
Bartlesville
Joplin
Stillwater
Tulsa
Oklahoma City
Norman
Shawnee
Muskogee
Fayetteville
ARKANSAS
Maximum Eclipse at 1:50 pm CDT
Fort Smith
McAlester
OKLAHOMA
Maximum Eclipse at 1:45 pm CDT
Ardmore
Russellville
99% partial solar eclipse = 0% total solar eclipse
Sherman
TEXAS
Hot Springs
Benton
Bonham
Paris
Frisco
McKinney
Arkadelphia
Plano
Greenville
Dallas
Sulphur Springs
Texarkana
Terrell
Mount Pleasant
Ennis
El Dorado
Corsicana
Athens
Tyler
Longview
LOUISIANA
Shreveport
90%
91%
92%
93%
94%
95%
96%
97%
98%
1:43
1:44
1:46
1:47
1:48
1:49
1:51
1:52
1:53
1 minute
2 minutes
2 min 30 sec
3 minutes
3 min 15 sec
3 min 30 sec
3 min 45 sec
4 minutes
4 min 10 sec
4 min 15 sec
4 min 20 sec
0
Scale
50 miles
N


Maximum Eclipse at 2:00 pm CDT
Maximum Eclipse at 1:55 pm CDT
ILLINOIS
MISSOURI
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
Belleville
Centralia
Mount Vernon
Springfield
Farmington
Carbondale
Marion
Cape Girardeau
Mountain Home
Poplar Bluff
Sikeston
Paducah
Kennett
Batesville
Jonesboro
Paragould
Conway
Searcy
Cabot
Jacksonville
Little Rock
Jackson
Barlett
Memphis
Southaven
Pine Bluff
Tupelo
Florence
Greenville
2:01
1:59
1:58
1:57
1:56
1:54
1 minute
2 minutes
2 min 30 sec
3 minutes
3 min 15 sec
3 min 30 sec
3 min 45 sec
4 minutes
4 min 10 sec
4 min 15 sec
99%
98%
97%
96%
95%
94%
93%
92%
91%
90%


90%
91%
92%
93%
94%
95%
96%
97%
98%
99% partial solar eclipse = 0% total solar eclipse
Chicago
Lake Michigan
Aurora
Joliet
Galesburg
Peoria
Kankakee
Benton Harbor
Gary
South Bend
Elkhart
Maximum Eclipse at 3:10 pm EDT
Bloomington
Springfield
Decatur
Urbana
Maximum Eclipse at 2:05 pm CDT
3:06 pm EDT
3:07
3:08
3:09
INDIANA
Lafayette
Kokomo
Marion
Crawfordsville
Muncie
Noblesville
Anderson
Fishers
New Castle
Indianapolis
Greencastle
Terre Haute
ILLINOIS
2:04
2:03
2:02
2:01
Effingham
4 minutes
Greenwood
Franklin
Connersville
Shelbyville
Martinsville
4 min 2 sec
Bloomington
4 min 4 sec
Greensburg
Columbus
1 minutes
2 minutes
2 min 30 sec
3 minutes
3 min 15 sec
3 min 30 sec
3 min 40 sec
3 min 50 sec
4 minutes
Centralia
Mount Vernon
3 min 52 sec
4 min 2 sec
4 min 4 sec
3 min 54 sec
3 min 56 sec
3 min 58 sec
4 min 6 sec
Vincennes
Bedford
Seymour
Washington
Jasper
Carbondale
4 min 8 sec
4 min 6 sec
Marion
Evansville
Henderson
New Albany
Louisville
Cape Girardeau
Owensboro
KENTUCKY
Frankfort
Lexington
Madisonville
Paducah
Hopkinsville
Bowling Green
0
Scale
50 miles
N


Kalamazoo
Battle Creek
Pontiac
Detroit
Ann Arbor
Windsor
Maximum Eclipse at 3:15 pm EDT
ONTARIO
London
3:18
3:17
3:16
3:14
3:13
3:12
3:11
MICHIGAN
1 minutes
2 minutes
2 min 30 sec
3 minutes
3 min 15 sec
3 min 30 sec
3 min 40 sec
3 min 50 sec
3 min 52 sec
3 min 54 sec
3 min 56 sec
3 min 58 sec
Toledo
Lake Erie
Erie
Conneaut
Ashtabula
Fort Wayne
Defiance
Bowling Green
Fremont
Sandusky
Lorain
Elyria
Euclid
Mentor
Cleveland
Meadville
Bluffton
Findlay
Norwalk
Lima
Medina
Kent
Warren
Akron
Wapakoneta
Ashland
North Canton
Youngstown
Wooster
Mansfield
Massillon
Canton
Marion
Sidney
Greenville
Troy
Urbana
Marysville
Delaware
Mount Vernon
Richmond
Dublin
Springfield
Dayton
OHIO
Columbus
London
Springboro
Oxford
Xenia
Zanesville
Lancaster
Wheeling
Pittsburgh
99%
98%
97%
96%
95%
94%
93%
92%
91%
90%
PENNSYLVANIA
WEST VIRGINIA
Fairfield
Cincinnati
Covington
Morgantown
Parkersburg
Clarksburg
Huntington
Charleston


92%
93%
94%
95%
96%
97%
98%
99% partial solar eclipse = 0% total solar eclipse
Georgian Bay
Lake Huron
Parry Sound
Pembroke
Wiarton
Owen Sound
Orillia
Barrie
ONTARIO
Peterborough
Orangeville
Maximum Eclipse at 3:20 pm EDT
Toronto
Oshawa
Belleville
Kingston
Kitchener
Watertown
Lake Ontario
Hamilton
London
Lockport
Niagara Falls
Rochester
Oswego
Batavia
Buffalo
Syracuse
Geneva
Auburn
Dunkirk
Lake Erie
Erie
Conneaut
Ashtabula
Jamestown
Ithaca
Meadville
Elmira
Binghamton
PENNSYLVANIA
Warren
Youngstown
Williamsport
Scranton
Wilkes-Barre
Beaver Falls
3:17
3:18
3:19
3:21
3:22
3:23
3:24
1 minute
2 minutes
2 min 30 sec
3 minutes
3 min 10 sec
3 min 20 sec
3 min 25 sec
3 min 30 sec
3 min 32 sec
3 min 34 sec
3 min 36 sec
3 min 38 sec
3 min 40 sec
3 min 42 sec
3 min 44 sec
3 min 46 sec
3 min 48 sec
3 min 50 sec
3 min 40 sec
3 min 42 sec
3 min 44 sec
3 min 36 sec
3 min 38 sec
0
Scale
50 miles
N


QUÉBEC
Trois-Rivières
Joliette
Victoriaville
Saint-Georges
St.-Jerome
Drummondville
Ottawa
Maximum Eclipse at 3:25 PM EDT
Montréal
Sherbrooke
Cornwall
Massena
Ogdensburg
Brockville
Plattsburgh
Burlington
Montpelier
MAINE
NEW HAMPSHIRE
VERMONT
NEW YORK
Utica
Saratoga Springs
Schenectady
Albany
Concord
Manchester
Lewiston
Portland
MASSACHUSETTS
Pittsfield
Lowell
Salem
Boston
Worcester
Springfield
CONNECTICUT
Poughkeepsie
Hartford
Providence
RHODE ISLAND
Waterbury
New Bedford
3:26
3:27
3:28
3:29
3:30
1 minute
2 minutes
2 min 30 sec
3 minutes
3 min 10 sec
3 min 20 sec
3 min 25 sec
3 min 30 sec
3 min 32 sec
3 min 34 sec
3 min 36 sec
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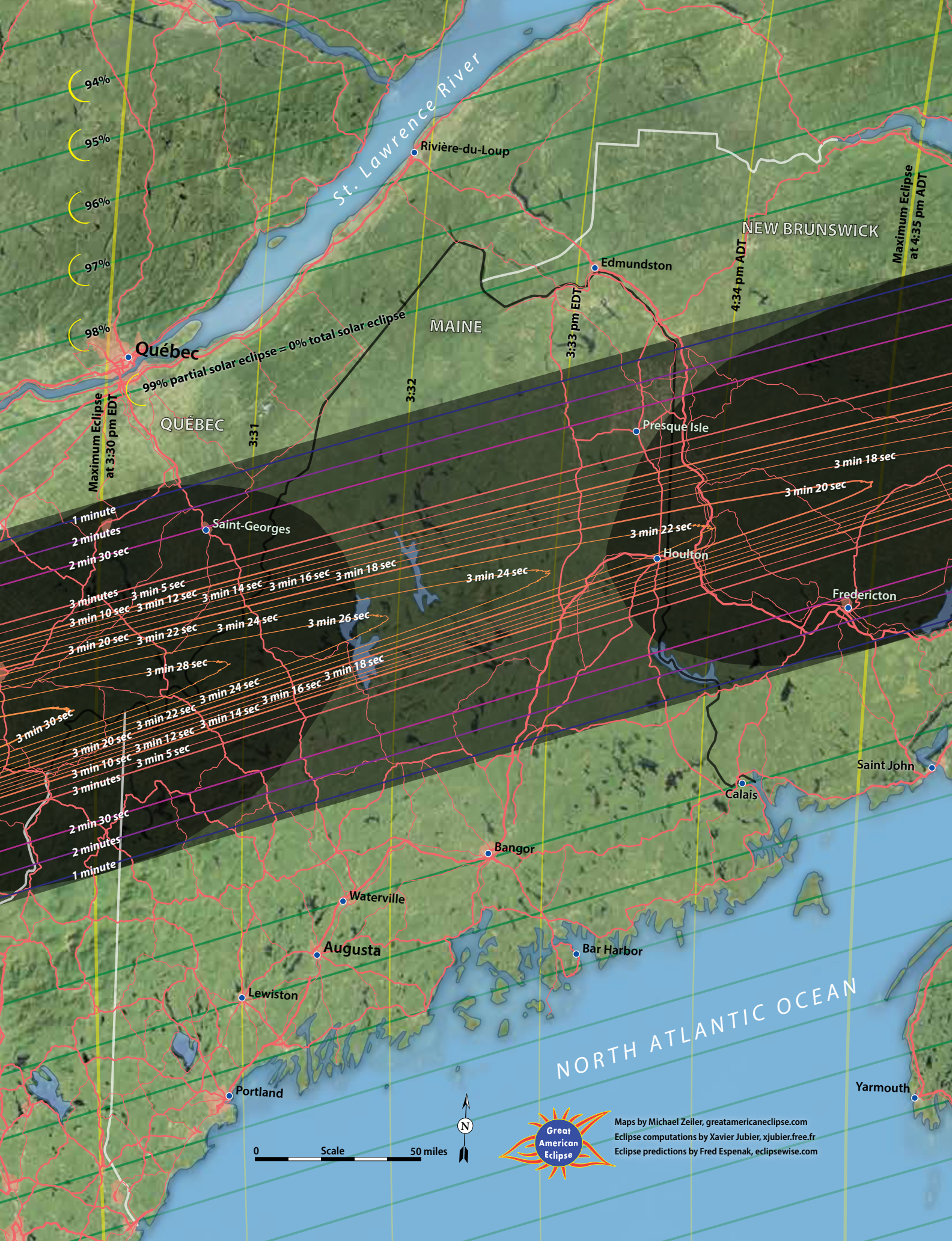
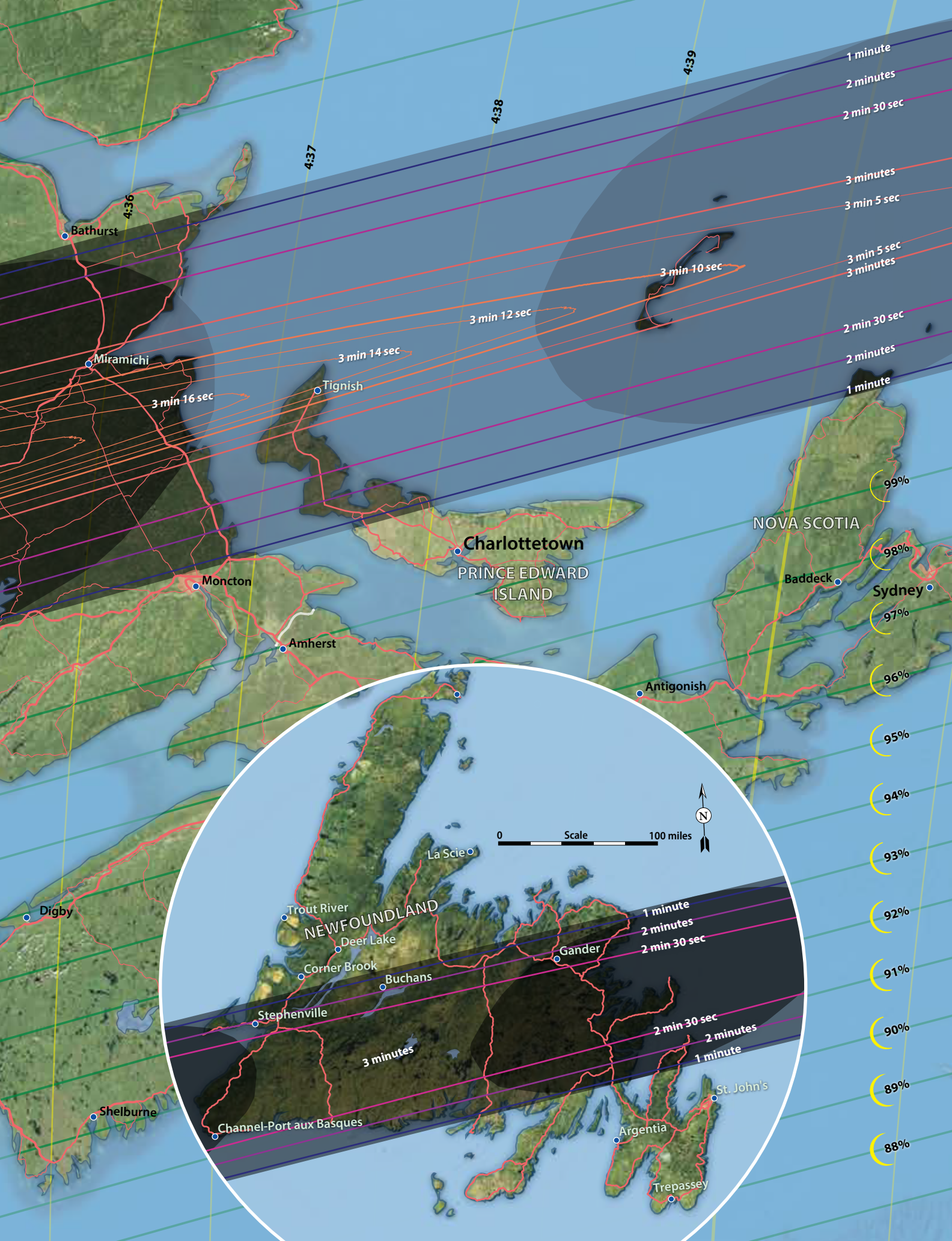


Maps by Michael Zeiler, greatamericaneclipse.com
Eclipse computations by Xavier Jubier, xjubier.free.fr
Eclipse predictions by Fred Espenak, eclipsewise.com


4:36
4:37
4:38
4:39
1 minute
2 minutes
2 min 30 sec
3 minutes
3 min 5 sec
3 min 10 sec
3 min 12 sec
3 min 14 sec
3 min 16 sec
Bathurst
Miramichi
Tignish
Charlottetown
PRINCE EDWARD ISLAND
NOVA SCOTIA
Moncton
Amherst
Baddeck
Sydney
Antigonish
99%
98%
97%
96%
95%
94%
93%
92%
91%
90%
89%
88%
Digby
Shelburne
0
Scale
100 miles
N
La Scie
Trout River
NEWFOUNDLAND
Deer Lake
Corner Brook
Buchans
Gander
Stephenville
Channel-Port aux Basques
St. John's
Argentia
Trepassey

25 TIPS FOR THE BEST ECLIPSE PHOTOS

Cameras, tripods, filters, and more: Are you prepared to take pictures of the Great North American Eclipse? BY MICHAEL E. BAKICH

Taking good eclipse photos is harder than it looks. The last Great American Eclipse, on Aug. 21, 2017, was photographed by hundreds of thousands of people — and many of them were probably disappointed in their results. Overexposure, blurriness, and camera malfunctions are all concerns if you aren't prepared. Here are some tips you can follow that might help you take better pictures of eclipses this month and beyond.

Preparing a camera for the Nov. 14, 2012, total eclipse over Australia.

ALAN DYER

1 Select your equipment

If you're reading this, you have at most five weeks before the big event. That means you'll need to decide soon what optics you'll be shooting through. It could be a camera lens or the tube of a telescope. Also decide what you'll be shooting with: a digital single-lens reflex camera (DSLR) or mirrorless camera, a point-and-shoot camera, or your cellphone. Most importantly, you'll need an approved solar filter that goes over the front of your optics.

2 Practice as much as you can

Don't take your first pictures of the Sun on eclipse day. Take some test shots first. To do that, go outside on a sunny day, aim your filtered camera at the Sun, and shoot. (NOTE: When not looking through your filtered optics, wear solar glasses to protect your eyes as you look toward the Sun.) Set your lens to a fixed aperture — somewhere between f/8 and f/16 — and take a range of exposures. Examine the images and narrow them down to the best two or three.

This 2017 total solar eclipse composition was taken in Wyoming.

BERND THALLER/FLICKR

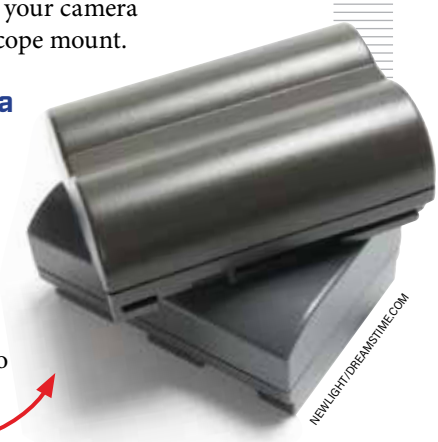
That's when to look at the EXIF data, where all the shooting details will be. Remember, the Sun remains bright throughout the eclipse, so you won't have to change exposure times until the disk is a thin crescent. At that point, add two more exposure stops.

3 Decide what you want to shoot

There are many ways to frame a shot of the eclipse. Look through back issues of *Astronomy* or check out the Picture of the Day images on Astronomy.com for inspiration. You could mount your camera on a tripod and take a single shot during totality. Or you could take a sequence that shows the progression. To do this, aim your camera at the Sun's position at mideclipse and shoot about once every five minutes. You can later combine these shots into one picture using various software. If you want to take close-up shots of the whole eclipse or starting just a few minutes before totality, the best way is to attach your camera to a motorized telescope mount.

4 Bring extra batteries

Do this so your equipment won't shut down. And make sure all devices are fully charged in advance. You can never be too careful.



NEWLIGHT/DREAMSTIME.COM

5 Check your camera's memory card

Make sure the memory card in your camera has at least twice the space you think you'll need to photograph the eclipse.

6 Arrive well before the event starts

Don't scramble to set up minutes before the eclipse. Beat the crowd by getting there early. You can pick out a prime spot, set up your equipment, test it, and deal with any problems without stressing over time.

7 Use an approved solar filter

As should be clear from how often it's repeated, viewing and photographing the eclipse must only be done through an approved solar filter. For solar glasses, look for the ISO 12312-2 rating — the international standard for direct solar viewing. For your eyes to be safe when viewing through a filtered camera, stricter standards apply. The filter — which goes on the front of your optics — must reduce the visible light by a factor of 128,000.

8 Secure your filter

Most solar filters made for telescopes fit tightly on the front of the tube. Camera lenses, however, come in a wider variety of sizes. If your filter is even slightly loose, secure it with painter's tape, which removes easily and will not leave residue.

9 No filter during totality

The Sun's disk outshines the corona by a million times. That's why we never see the corona except during totality, when it is the only visible light. To photograph this event, you'll need to remove the filter from your lens (or telescope) once totality occurs. Also, the corona is really bright close to the Sun's edge but fainter far from the Sun. Usually, at a distance of about 1 solar diameter, your eyes won't see the corona, but cameras will. So bracket your exposures during totality across a wide range of shutter speeds to capture the full dynamic range of the scene.

The EclipSmart Universal Solar Filter is one of many cost-effective solar filters that works on scopes as well as camera lenses of varying sizes.

10 Get a camera-to-scope adapter

If you're coupling your camera's body to a telescope, you'll need both a T-ring and a T-adapter. The T-adapter screws into the camera-specific T-ring. The adapter's other side is a 1¼-inch-diameter tube that slides into your telescope's focuser just like an eyepiece, making your scope a giant telephoto lens.

11 Use a remote shutter release

Why take the risk of possibly moving your camera and blurring your photo just by hitting the shutter? Devices that trip the shutter for you are small, easy to use, wireless, and inexpensive.

12 Focus is critical

Turn off your lens' autofocus. That feature doesn't work well when aimed at blue skies, nor in low-light conditions. Also, most camera lenses can now focus past infinity, so you can't just turn the focuser all the way until it stops. Focus by aiming at a distant earthly object. Then don't touch the focus ring again — or secure it with painter's tape, as mentioned in No. 8.

Do not use eclipse glasses as a replacement for a solar filter when photographing totality.

ROMEO DURSCHER/NASA GODDARD/FLICKR

TRIPOD: ROBERTSROB/DREAMSTIME.COM. MEMORY CARDS: JAROSLAW GRUDZINSKI/DREAMSTIME.COM. SOLAR FILTER: CELESTRON

13 Prep during first contact

The entire total eclipse lasts 2 hours 19 minutes or more in the U.S., but a lot of that time is a slow build-up. Remember, this event is all about totality. If you're concentrating on capturing those three to four minutes, take the hour after first contact to do your final check to see that everything works. Then rehearse your plan a few more times.

14 Camera/lens field of view

Many DSLRs exist today, and they all accept a variety of lenses. Plus, not all of them have the same size sensors (chips). Here is an easy way to figure out a lens' field of view (FOV) on your camera: FOV = 2 * arctan (0.5 * *s*/*f*) * 57.3. In this equation, *s* stands for sensor dimension in millimeters and *f* is the focal length of the lens in millimeters. Note that this formula is for just one dimension (width or height) of your chip. If you want the FOV in both dimensions, do this calculation twice. (Refer to "Choosing a camera for eclipses," in the December 2023 issue, for more details.)

15 A telescope's field of view

But what if you'll be attaching your camera to a telescope? The calculation is the same. Use the formula in No. 14, but insert your scope's focal length for *f*. You'll find it on the tube, on the ring that secures the front optic, or in your instruction manual.

16 The corona's size

If you're photographing totality, the Sun's disk is just the beginning. Between second and third contacts, it disappears. What will be visible is the corona, which stretches between 1 and 1.5 solar diameters from the Sun's edge. A corona measuring 1 solar diameter will have a diameter of 2.5°. A 1.5-solar-diameter corona will span 3.5°.

17 The Sun's size on your chip

After you figure out the FOV of your camera and lens combination, it's simple to calculate how much of your camera's sensor the Sun will cover. Let's say it has an FOV of 6° in the horizontal direction. The Sun and Moon both have an angular diameter of 0.5°. So, the Sun's width on your image will be 0.5 divided by 6, or 8.3 percent of the FOV.

18 Your lens' focal length

To capture the Sun during the partial phases, make sure you don't pick a lens or telescope that restricts the view to less than 0.5° in the vertical dimension. Increase this to 3° or even a bit more if you want to photograph the corona.

LENS FOCAL LENGTH vs. IMAGE SIZE

*Approximate focal length for most crop-sensor DSLR cameras.

COURTESY OF FRED ESPENAK, WWW.MRECLIPSE.COM

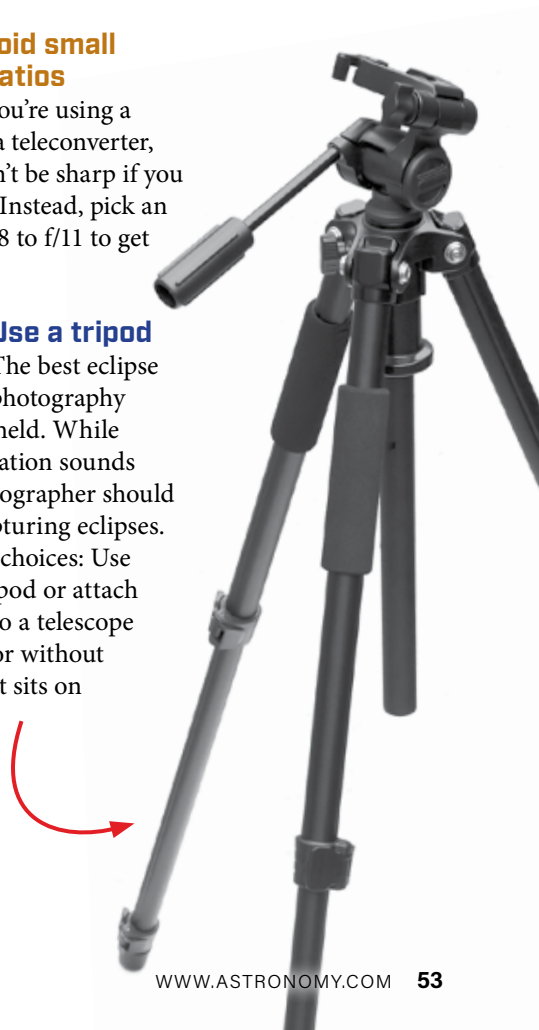
The illustration shows an eclipse at different focal lengths on a full-frame and a crop-sensor DSLR.

19 Avoid small f-ratios

If you're using a zoom lens or a teleconverter, the image won't be sharp if you shoot at f/1.4. Instead, pick an f-ratio from f/8 to f/11 to get better images.

20 Use a tripod

The best eclipse photography is never handheld. While image stabilization sounds good, no photographer should trust it for capturing eclipses. You have two choices: Use a standard tripod or attach your camera to a telescope mount (with or without the scope) that sits on a tripod.



21 Camera write speed

How fast you can take pictures depends on your camera-to-memory-card write speed. See how fast your camera will let you take pictures by checking your SD card, which often has the write speed in megabytes per second (MB/s) listed on the front. The latest cameras have write speeds at a minimum of 10 MB/s, while older DSLRs and point-and-shoot cameras are slower.

NIGHTMARE9/DREAMSTIME.COM

22 Consider an intervalometer

An intervalometer lets you take time-lapse photos. If you plan to capture close-up images during the whole eclipse, this device will let you take exposures at any interval you choose. Search online and you'll find a variety of intervalometers, also called timer remote controls, for many Canon and Nikon DSLRs. Newer cameras often have built-in intervalometers — sometimes as part of time-lapse functions — or may be controlled remotely via a smartphone.

DMITRII MELNIKOV/DREAMSTIME.COM

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Try displaying your eclipse shots in a unique way by combining a sequence of images with photo software.

23 Totality seems brief

As amateur astronomer Norm Sperling wrote in an essay titled "Sperling's Eight-Second Law" in the August 1980 issue of *Astronomy*, "Everyone who sees a total solar eclipse remembers it forever ... the curdling doom of the onrushing umbra, the otherworldly pink prominences, and the ethereal pearly corona. And incredibly soon, totality terminates. Then it hits you: 'It was supposed to last a few minutes — but that couldn't have been true. It only seemed to last eight seconds!'" I hope you get his point. If you encounter a problem that takes more than a few seconds to fix, stop! Forget about photographing the eclipse and instead just enjoy the view.

24 Photograph everything

Bring a second camera (or use the camera in your phone) to make sure you can chronicle what's happening around you before and after the eclipse. Doing so won't ruin your experience and will document the activities of your family, friends, or astronomy club.

25 Be quick about processing your shots

Processing your photos quickly isn't so much advice for this eclipse, but rather advice for any images, especially ones you have put so much work into. Don't let those images just sit on your computer or memory card and get forgotten about. Go through each one as soon as you can. And if you want to, email your best ones to readergallery@astronomy.com. Even if you aren't interested in getting the images published, processing them quickly will also allow you to share the excitement with the special people around you.

Michael E. Bakich *is an* Astronomy *contributing editor. This will be his 15th total solar eclipse.*

INDEX *of* ADVERTISERS

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Egypt, Australia, China, and Malaysia are just a few

THE NEXT 20 YE

IT'S APRIL 9, 2024 — the day after the Great North American Eclipse. If you missed it because of clouds, personal commitments, or travel problems, you may be wondering when your next chance will be. And if, on the other hand, you experienced it under a clear sky, you are probably ready for the next one.

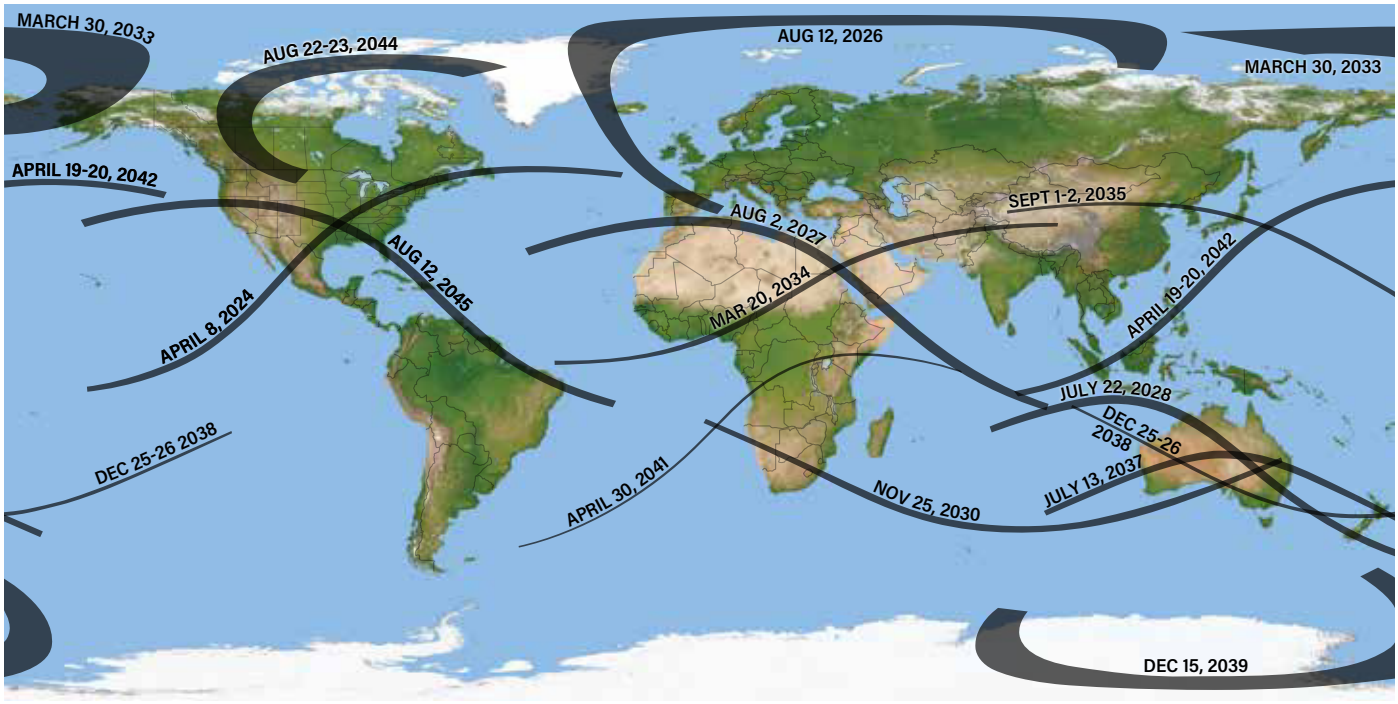
The following list contains the eclipse highlights of the next two decades. Target the one (or more) you want to see and learn all you can about it. Whenever it occurs, now is not too soon to start planning.

This decade

The next total solar eclipse after April 8 occurs Aug. 12, 2026. However, because its path of totality is short-lived and mostly in secluded areas, it might be a less popular target. It will touch Greenland, Iceland, and northern Russia, as well as a small part of Portugal and Spain.

But don't despair. The eclipse of our lifetimes follows almost a year later. And maximum totality happens in a location where, at that time of year, clouds are nearly impossible. On Aug. 2, 2027, the Moon's umbra will touch 12 European, African, and Middle Eastern countries and

An eclipse on Aug. 11, 1999, is seen from Hasankayef in southeastern Turkey. The country will experience partial eclipses on Aug. 2, 2027, and March 20, 2034. ALAN DYER



ABOVE: This map shows the locations of the eclipses from this year until the next major U.S. eclipse on Aug. 12, 2045. *ASTRONOMY:* ROEN KELLY

RIGHT: A line of ram-headed statues are pictured at the Karnak temple complex in Luxor, Egypt. This location also serves as a unique visual for those viewing the Aug. 2, 2027, eclipse. DIEGO DELSO/WIKIMEDIA COMMONS

territories. The prized destination will be Egypt.

My chosen spot for 2027 is Karnak, the great temple complex in the city of Luxor. There, at one of the most visited historic sites in Egypt, you can look overhead as the Moon completely covers the Sun for 6 minutes 22 seconds. This duration won't be surpassed until June 3, 2114. Now that's observing!

The next totality crosses Australia on July 22, 2028. Greatest duration, 5 minutes 10 seconds, occurs just after the umbra hits the country 100 miles (160 kilometers) west of the small town of Wyndham, which lies in the state of Western Australia.

From there, the umbra moves southeast, encountering few towns until it crosses into New South Wales. Then, just before it heads out to sea, the umbra covers Australia's most populous city, Sydney. A camera just south of the Sydney Opera House could capture it and perhaps the Sydney Harbour Bridge with the eclipsed Sun 29° above the northwestern horizon. There, totality will last a worthy 3 minutes 44 seconds.

The final total solar eclipse of the decade will happen Nov. 25, 2030. It touches four countries on the African continent — South Africa, Botswana, Namibia, and Lesotho — and Australia. Maximum duration of totality, 3 minutes 44 seconds, occurs in the Indian Ocean some 1,370 miles (2,200 km) east-southeast of Durban, South Africa, a distance roughly equivalent to that from Houston to Toronto. When the umbra finally

of the locales to catch totality in the coming decades. **BY MICHAEL E. BAKICH**

ARS OF ECLIPSES

ABOVE: Uluru, also known as Ayers Rock, is located in the Australia's Outback and will experience an impressive 3 minutes 10 seconds of totality on July 13, 2037. ANGELO GIORDANO

LEFT: At the city of Qinhuangdao in China, a portion of the Great Wall meets the sea. Nicknamed the "Old Dragon's Head," it is a perfect spot to see 1 minute 56 seconds of totality in 2035. MATTHEW STINSON/FLICKR

touches the Australian coast, the Sun will stand 17° high and totality will last 2 minutes. Adelaide will be a good base for travelers. It lies 186 miles (300 km) south of the path.

The 2030s

The stretch from 2031 through 2040 contains seven total solar eclipses. Three of these are of particular note. The first will take place March 20, 2034. It touches 13 countries, slicing across Africa and continuing into the Middle East and China. The maximum duration of totality, 4 minutes 9 seconds, occurs in Chad, but totality exceeds three minutes along the center line throughout Africa.

Over a year later, totality will also take place in China — along with Japan, South Korea, and North Korea. Most notably, the eclipse on Sept. 20, 2035, will be visible in Beijing — with a population of 21.5 million people — for a maximum totality of 1 minutes 35 seconds. For a longer look, head 186 miles (300 km) east to the port city of Qinhuangdao to get an image of an eclipse over the Great Wall.

Another notable event will occur July 13, 2037. The Moon's umbra, traveling west to east, creates a more than 1,900-mile-wide (3,100 km) path that cuts Australia in half. Maximum totality reaches 3 minutes 58 seconds. A spectacular photo op will be possible at Uluru (also known as Ayers Rock) in the heart of the Outback, where travelers will experience 3 minutes 10 seconds of totality. The next eclipse will also cross Australia and New Zealand on Dec. 26, 2038.

The 2040s

The first total solar eclipse of this decade will be on April 30, 2041. It will cut through five countries in central Africa. Maximum totality, 1 minute 51 seconds, occurs off the Angolan coast near its capital, Luanda.

The eclipse on April 20, 2042, is of note because of its maximum duration of totality: 4 minutes 51 seconds. You'll need to be aboard a ship off the coast of Japan to experience that length, or you could choose to be on land in the Philippines, where totality will exceed 4 minutes 20 seconds. Other options include Malaysia, Indonesia, and Brunei.

The final eclipse I'll mention will be the next Great American Eclipse. On Aug. 12, 2045, the path will stretch from California to Florida, touching 15 states along the way, as well as the Caribbean Islands and Central and South America. And the maximum duration of totality, just off the Florida coast, is an amazing 6 minutes 6 seconds. But don't worry if you want to stay on land — at no point along the center line through Florida, which stretches some 370 miles (600 km), does totality dip below six minutes.

Indeed, the next few decades offer some diverse eclipse-viewing choices. Whichever you choose, I wish you clear skies.

Michael E. Bakich *is a contributing editor of* Astronomy *and co-author of* Atlas of Solar Eclipses: 2020 to 2045.

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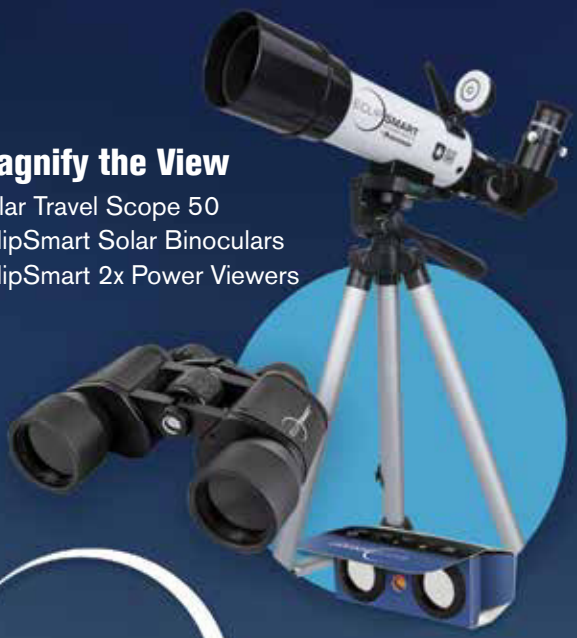

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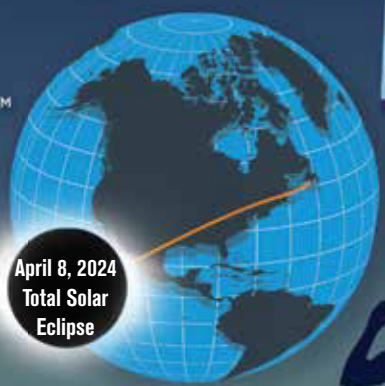

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