The Weather Observers Guide to

RAINBOWS

Written by Peg Zenko with special edit by Les Cowley

Even after the most destructive thunderstorms have just passed, the sky can display a bright, stunning blend of colors in the graceful, perfectly circular arc of a rainbow. The subject of song, verse and Biblical prophecy, rainbows are associated with light and peace. Many cultures have myths surrounding the rainbow. In Norse, it is called *Bifrost* (The Trembling Roadway). They are the easiest of atmospheric optic phenomena to spot, even though they occur in our observing area roughly an average of only 5% as often as the common 22-degree solar halo.

The first step in spotting rainbows is to recognize sky colors that are commonly mistaken for rainbows. The solar halo (*left*) is sometimes mistaken for a rainbow because it displays similar colors, and is also circular. The halo, however, appears *around* the sun, in a radial arc of 22 degrees, and the much larger rainbow is always *opposite* the sun. Another difference is that the red band of the halo

Continued ➔

*(**RAINBOWS** continued)*

appears on the inner circumference of the circle, and red is on the outside of the rainbow.

Another misconception is that a very frequent colorful solar companion, the sundog, is a little piece of rainbow. Sundogs (*right*) also appear near the 22-degree radius halo. In this instance it's difficult to detect an arc, but the obvious clue is that it is near the sun. The optic phenomena that most closely resembles a rainbow is the circumzenithal arc, or CZA. The startlingly bright CZA (*below*) occurs farther from the sun, almost directly overhead, and looks like a fragment of a disoriented and upside down rainbow.

The sundog, halo and CZA are all atmospheric optics made by tiny ice crystals, mostly in cirrus clouds. We'll take a closer look at optics in upper atmosphere ice crystals in a future issue.

A less obvious, but sometimes colorful, sighting is the corona and cloud iridescence. Like the rainbow, all coronae are made by water droplets, but from very small ones in newly formed clouds rather than rain. Coronae are also located very near the sun. This bright corona (*below*) from June 2003 also shows iridescence, or disorganized color bands.

We are all more familiar with the rainbow phenomena even though it is a relatively rare gem in comparison to other atmospheric occurrences like halos, sundogs, CZAs and iridescence for several reasons.

The first, and most obvious, is that by nature and safety concern we don't often look directly toward the sun, but away from it. How many times a year when you are racing the clock to get to work or school in the morning do you stop to look at the sun? The second is that rainbows are made by raindrops in the air much closer to the ground, and here in Wisconsin that means only in the seasons that have temperatures above the freezing point. When we think of The Packers playing on the "Frozen Tundra" of Lambeau Field, it's hard to believe that +32 F occurs very often!

Continued ➔

*(**RAINBOWS** continued)*

Another condition that adds to rarity of occurrence is the simple fact that not just any old drops are capable of producing a rainbow. Let's look at the "recipe" for a rainbow: Direct sunshine refracted by almost perfectly spherical raindrops. Adding a drop distortion of only 1% is enough to spoil the bow! As with any other brew, the ingredients must be in the correct proportions. If the drops are too fine the colors diffuse, and very large drops distort as they fall. A rainbow always appears opposite the sun, called the antisolar point. This means that a low sun will produce a high, arching bow. Bows at noon are very low, so unless you are in a plane or on a mountain, the sun must be low enough for the bow to be visible. The variables are many, and the formula complicated, but when they fall into place we see…….

….a glorious sight spanning the sky! The photo above shows 2 separate bows, the brighter primary bow and the outer faint secondary. The band between the bows is darker than the surrounding sky, and is called Alexander's dark band. The sky inside the primary is brighter because raindrops there reflect some light back to our eyes. Similarly, drops outside the secondary bow are "lit" by the light they reflect. But raindrops between the bows cannot send any light back to us. Michael's photo (*above*) is also an excellent example of a rainbow wheel. The dark spokes radiating from a central point are actually rain or cloud shadows.

Continued ➔

*(**RAINBOWS** continued)*

Very often if you look carefully on the inner arc you will see additional color bands, mostly green and violet hues, called supernumeraries. They are formed by very small raindrops and can range from very crisp, defined bands (*left*) to delicate pastel shadings.

Rainbows come in other forms besides the classic one pictured here. On rare occasion you may see multiple bows that cross each other, called reflection bows. Another rare bow is a twinned bow: two complete bows so closely spaced that they appear to overlap.

A deeply colored sunset may produce a bow that appears to be mostly bright red and/or yellow. In school we are taught the fictional name of ROY G BIV as a mnemonic for remembering red, orange, yellow, green, blue, indigo and violet for the science pop quiz on the refraction of white light. In truth, the colors of the rainbow overlap and are impure mixes. The size of the water droplet determines how vivid the color will appear to the eye. Large drops produce deep, saturated colors (*right*) and smaller droplets produce delicate color (*see title photo*).

Whether the rainbow is a high arc soaring skyward at sunrise or sunset, or a low bow (*below*) nearly hiding on the horizon, the one you see is yours alone! Remember that the light rays reflected back travel in a straight line and the ones entering your eyes are seen by no one else. The drops themselves can be nearly right in front of you or miles up in the clouds, but the effect is the same. The next time an isolated rain shower is followed by breaks in the clouds, look opposite the sun for the rainbow and note its position and other bows around it. You might be rewarded with a treasured phenomena of Nature created just for you, one more rare and complicated than you might have ever imagined.

Continued ➔

*(**RAINBOWS** continued)*

Optics expert Les Cowley summarizes, “Let's be honest, a rainbow is so stunningly large and bright that almost no one could overlook it, and it is so entrenched in our folklores and myths that it is part of us in ways that halos will never be.”

The Weather Observers Guide to Rainbows was written by Peg Zenko, with special edit by Les Cowley
All photos by Peg Zenko at http://www.tangentphotos.com unless otherwise noted

Special photo credits:

Gary Baier, Packerland Chapter AMS (sailboats & rainbow)
Michael Ellestad *http://www.geocities.com/bowlturner/my_weatherpics.html* (rainbow wheel)
Lauri Kangas *http://www.photon-echoes.com* (circumzenithal arc)
Eva Seidenfaden *http://www.engl.paraselene.de* (low rainbow)

For more information and images visit Atmospheric Optics at
http://www.sundog.clara.co.uk/atoptics/phenom.htm
