

Cover illustration

Are you for real?

According to Italian legend, Morgan le Fay ("Morgan the Fairy") was half sister to King Arthur and worked her atmospheric magic with the mirage. She learned her skills from Merlin the magician. Her namesake mirage, found over the Strait of Messina, is the "Fata Morgana." This ethereal display has commanded the fascination, and the terror, of mariners since they first plied the strait between Sicily and Italy, although the display has been seen elsewhere. But, what is this phenomenon?

Mariners, ancient and contemporary, have understood that, when special conditions exist, a mirage may appear over a distant watery horizon, revealing features normally hidden behind the curve of the earth. Few understand why.

When the surface of the ocean, or landmass, is colder than the air above, the surface will cool the first few metres of overlying air. Above those first few metres of colder air, the next layer of air may be significantly warmer than both the air directly overlying the surface and the surface itself. This is particularly true of bright, reflective surfaces, such as snow or ice. A "layer cake" of temperature, consisting of a cold surface at the bottom with cold air overlying the surface followed by a warmer atmospheric layer, creates the potential for a mirage. Sometimes, a temperature inversion will provide a layer of warmer air sandwiched between layers of colder air, even some distance above the surface.

Light travels at its maximum speed in a vacuum. As light passes through any medium, including air, the light wave will slow as density increases. Generally, the density of air decreases with altitude as the atmospheric pressure decreases exponentially as the atmosphere becomes thinner. But, with conditions that produce mirages, air temperature, and hence density, can change over short distances. As light travels through a temperature layered atmosphere, the light will be bent or refracted and travel

toward the colder, denser air. So, if the layered air near the earth is colder and the air temperature increases with altitude, light rays will be bent towards the colder denser air, and hence towards the earth.

The Fata Morgana, then, exists when a cold surface has an overlying cold air mass with warmer air layered above that. As the light rays emanating from an object below the horizon encounter such layered masses, the rays are bent towards the earth and hence around the curvature of the earth. The observer sees the *apparent* position of the image above its real position; indeed, the image may be elevated well above the horizon. Depending on the conditions, there may be discontinuities as seen at the top of the cover. This is a *superior* mirage.

The reverse atmospheric conditions also exist and probably are more commonly seen by most of us since we drive to work and are not seafaring. A black tarmac road will absorb the sun's energy and will radiate this heat into the few metres of air immediately above the surface. In this case, the air temperature adjacent to the hot surface is highest and cools with altitude.

The *inferior* mirage, as seen at the bottom of the cover, shows that light rays, which would otherwise be directed

downward towards the surface and would never strike the observer's eye are bent upwards because of the cooler, denser medium that these rays strike on their journey towards the surface. Hence, these rays from the sky that would strike the surface a mile away are now bent upwards from the surface and seem to the observer to come *from* the surface. This refraction makes it appear as if the sky is actually below the mountain in the scene at the bottom of the cover. Our brain rejects that notion, but can make sense of the scene by interpreting it as a reflection from a water surface. In the photograph, a lake appears to be present where there is only a dry pan in the desert of the Great Basin in the American West.

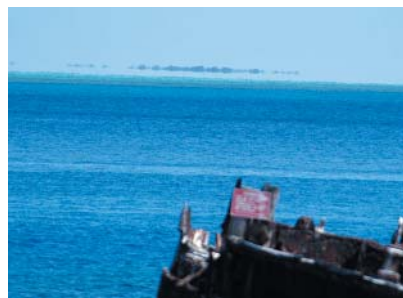
These inferior mirages have their own history and must have bedevilled the early pioneers of the American West as they travelled across the Great Basin between the Rockies and the High Sierra. These pilgrims timed their approach to the Sierra so they would complete their journey before winter, so they were in the basin during the time that minimal rain would fall. Water would have been a great challenge and these mirages must have been maddening, for the promise (and threat) of a lake would prove illusory time after time.

Sometimes these mirages can appear together with an inferior and superior mirage in the same image with a telltale vanishing line in the middle of the mirage (see fig on this page). But that explanation will be for another time.

Observing these mirages, one may wonder, "Are you for real?" The answer is, of course, yes, and no!

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Superior and inferior mirage photographed off Heron Island on the east coast of Australia. Note that the islands seem to hang above the water, but there also appears to be a reflection of these same islands. The midline of that mirage display, where it appears to be a reflection, is called a vanishing line.

Photograph on the top of the cover by Robert Greenler from his book *Rainbows, Haloes, and Glories* (available through www.blueskyassociates.com). Thanks to Robert Greenler for his comments on the essay. Photograph on the bottom of the cover and on this page by the author.



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