

Why the Strongest Infrared Band May Not Give the Clearest Image

A glowing kiln and a quiet cabinet both emit infrared



Hot and room-temperature surfaces share a scene, but emit different infrared spectra.

The kiln is easy to notice. The cabinet beside it looks ordinary. Both emit infrared radiation, but their spectra - the distribution across wavelengths - are very different. Hotter objects shift their strongest emission toward shorter wavelengths. An everyday surface at 300 K, about 27 °C, has a blackbody peak near 9.66 μm (micrometres, or millionths of a metre). At 600 K, about 327 °C, that peak moves to 4.83 μm . [NASA explains the temperature trend](#); the values here are calculated using [NIST constants](#).

Those peaks fall within common long-wave infrared, or LWIR, and mid-wave infrared, or MWIR, bands. It is tempting to stop there: choose the band containing the peak. That misses how a camera makes a useful image.

An uncooled microbolometer senses a tiny temperature change caused by absorbed radiation. Its electrical resistance changes with that heating. It needs no cryogenic cooling, although detector temperature still affects its response. [NIST describes this mechanism](#).

A cooled photon detector converts incoming photons into an electrical signal. Cooling reduces internally generated dark current, helping weak scene signals stand out. NASA uses the same underlying principle in infrared astronomy, where instrument cooling also reduces unwanted infrared emission from nearby hardware. Its spacecraft temperatures are specific to those instruments. [Read NASA's explanation](#).

Thus, a camera can work well in a band carrying less source radiation because its detector, optics and noise performance differ. “Cooled” and “MWIR” describe different properties; they are not interchangeable definitions. Ask for the actual detector, spectral response and operating conditions.

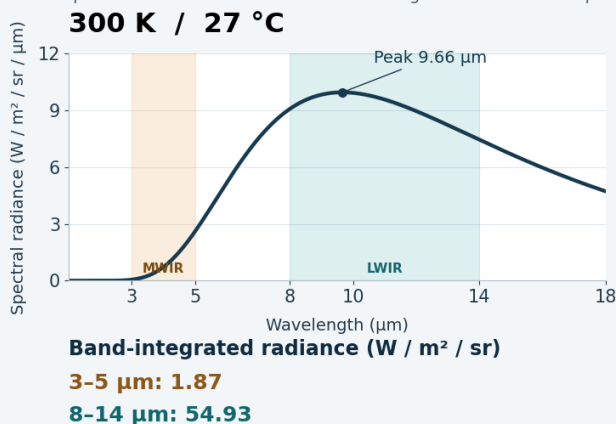
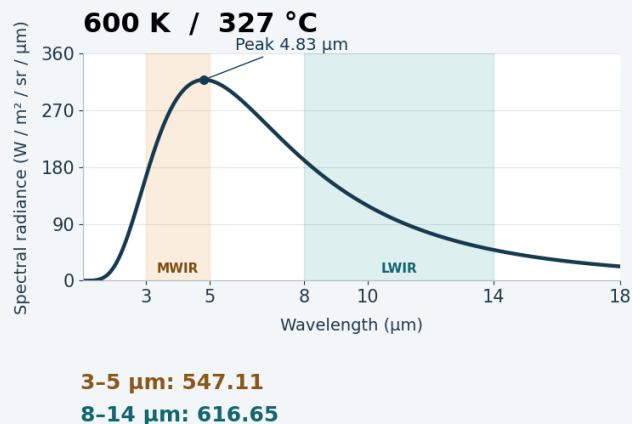
The source spectrum tells you what radiation is available. The whole camera determines what detail survives.

A peak is not a band total

The peak moves. The camera decision stays open.

Calculated blackbody emission • source temperature only

Each panel uses its own vertical scale. Shading marks the two comparison bands.



At 600 K the peak is inside MWIR, yet the wider LWIR band still carries more total radiance.

Emissivity 1 • no atmosphere, lens or detector weighting • Planck law with current SI constants

Calculated source spectra and band totals. Each panel has its own radiance scale; air, optics and detector response are excluded.

Consider an ideal blackbody: a surface with emissivity 1, meaning it emits the maximum thermal radiation for its temperature. We calculated its spectral radiance with Planck's law, then added the values across two wavelength intervals: 3-5 μm and 8-14 μm . This is a source calculation before any atmosphere, lens, filter or detector response.

At 300 K, the integrated radiance is 1.87 $\text{W}/\text{m}^2/\text{sr}$ in 3-5 μm and 54.93 $\text{W}/\text{m}^2/\text{sr}$ in 8-14 μm . The latter is about 29 times larger. Radiance describes radiation from an area in a viewing direction. Here, sr means steradian, a unit of solid angle; these are not watts reaching a camera.

At 600 K, the corresponding values rise to 547.11 and 616.65 $\text{W}/\text{m}^2/\text{sr}$. The peak has moved into MWIR, yet the wider LWIR interval still contains more total radiance. A peak marks the tallest point on a curve. It does not describe the area beneath an entire band.

What changes after radiation leaves the surface?

Actual cameras weight each wavelength differently. Filters and lenses transmit some wavelengths better than others, and the detector has its own response. NIST's camera model explicitly combines the emission spectrum with this spectral weighting. [See the model in section 2.2.](#)

Air adds another wavelength-dependent filter. Water vapour and other gases absorb particular regions, so an atmospheric window is not uniformly transparent. [NASA describes these absorption bands.](#)

The useful quantity is the feature's signal difference from its surroundings after this whole path, compared with noise. The blackbody totals help explain the physics. They do not predict a model's viewing distance, prove an advantage in humid weather or establish temperature-measurement capability.

At 600 K the peak lies in MWIR, while the wider comparison LWIR band still contains more total radiance.

Twice the focal length can cost three quarters of the light

Suppose a camera has 12 μm pixels and a 50 mm focal-length lens. A simple distant-scene calculation gives an angular sample of pixel pitch divided by focal length: $12/50,000 = 0.00024$ radians, or 0.24 milliradians per pixel.

At 500 m, that is approximately 0.12 m per pixel. A 0.60 m feature spans five pixels. A

100 mm lens would put about ten pixels across it. These are geometric samples, not a promise that the feature can be identified.

Now consider the aperture. The f-number is focal length divided by entrance-pupil diameter, as described in [MIT's optics notes](#). Keeping a 25 mm pupil while doubling focal length changes f/2 to f/4.

Calculated lens option	50 mm, f/2	100 mm, f/4
Entrance pupil	25 mm	25 mm
Samples across the feature	5	10
Relative image irradiance	1	About 0.25

Irradiance is the power arriving per unit detector area. The final row uses the first-order relation that irradiance from a uniform extended scene varies approximately as $1/(\text{f-number})^2$. It assumes equal transmission, an on-axis distant scene and no vignetting. Thus, the longer lens spreads the scene over more pixels while delivering about a quarter of the irradiance to each equal-area pixel. A 50 mm pupil would keep the longer lens at f/2, at the cost of a larger optical aperture.

Real lenses add diffraction, aberrations and transmission losses. Exposure and processing also change what the operator sees. A low noise specification cannot restore detail that the optical system has blurred away. Compare field of view, aperture, pixel sampling and the displayed result together; digital enlargement adds no new optical samples.

More pixels across a feature help only when the optical signal and image quality remain sufficient.

Build a comparison that can survive the weather changing



Compare the same small feature and background at the same time, then repeat as conditions change.

Choose a specific decision: can the operator distinguish a narrow gap in a warm equipment panel from an unbroken panel at the required distance? Seeing the whole warm panel is easier. Record the small feature, its background and the viewing angle.

Place candidates close together and record simultaneously, so changing clouds or equipment temperature do not favour one recording. Match scene framing where possible. Record each lens, optical field of view, pixel count, aperture, exposure, focus and processing settings. Keep unmatched parameters visible in the record instead of crediting their effects to wavelength.

Repeat with a smaller feature-to-background difference, then with hot equipment elsewhere in the frame. If the gap disappears only in the second condition, hold focus fixed and compare gain or exposure changes before attributing the loss to wavelength. Use both stored source images and the operator's display. [NIST's testing approach](#)

includes optics, processing and display in the complete imaging result.

Repeat in relevant conditions: dry and damp air, expected sightline length and different times of day. Record what actually occurred; one clear afternoon cannot establish all-weather performance. Measure electrical power and time from power-on to a useful, stable image at the planned ambient conditions. Request model-specific cooler service information where cooling is fitted.

The Inventra S³ [SEG10 combines a 640 × 512 uncooled LWIR channel with a daylight camera](#). Its published thermal configuration uses 12 µm pixels and a 25 mm lens. Send Inventra S³ the required detail, distance, conditions, response time and power allowance, together with the comparison record. That gives the engineering team evidence for choosing a complete configuration.

Select the configuration that repeatedly supports the operator's decision within the available power and response time.

Sources and further reading

[Remote Sensing: Radiation; Absorption Bands and Atmospheric Windows](#)

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[Webb Telescope's Coldest Instrument Reaches Operating Temperature](#)

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[Calibration and Measurement Procedures for a High Magnification Thermal Camera](#)

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[The Physics of Information Technology: Optics](#)

Massachusetts Institute of Technology

[SEG10 - Dual Channel \(EO-LWIR\) Stabilised Gimbal System](#)

Inventra S³

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