

REFERENCE **point**

Selecting the right radar band for meteorological operations is more than a matter of checking off specifications; it's about balancing technical performance, regional weather needs and budget constraints. If money, energy and infrastructure weren't limiting factors, the robust S-band radar would likely be the choice for everyone. Its minimal attenuation and resilience in severe weather make it an ideal solution. However, the high costs associated with S-band radars, including purchase price, maintenance and infrastructure, necessitate exploring alternative options. This is why other radar bands, particularly C-band and X-band, are used widely across meteorology.

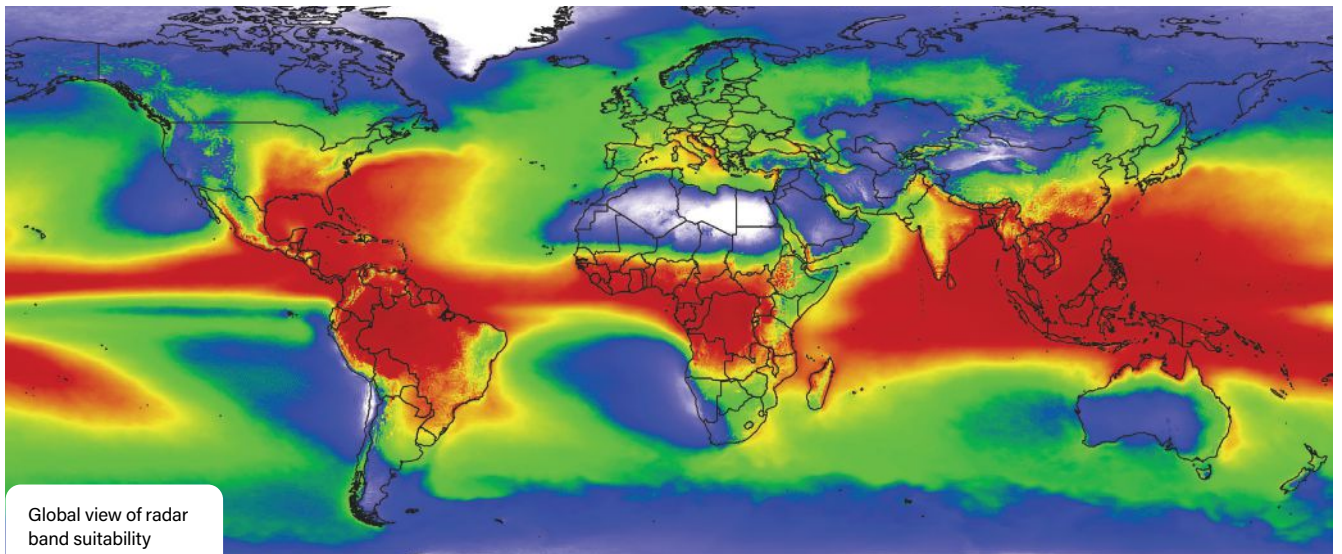
Each radar manufacturer will claim its solution is the best, often highlighting a range of benefits. While some of these arguments may be valid, others can be overly optimistic and

Meteopress presents its 21st century guide to radar purchasing – an independent, data-driven examination of radar band suitability for operational meteorology

commercially driven. This article provides an independent, data-driven examination of radar band suitability for operational meteorology, focusing on the unique strengths and practical considerations of each option. It also highlights how innovations in radar technology are enabling new possibilities for budget-conscious buyers and those in regions with specific weather challenges.

Decision-makers in meteorological services have two key responsibilities to their stakeholders: securing reliable solutions and ensuring the best value for investment. Staying current with technological advances is essential to fulfill these obligations, especially as the pace of innovation continues to reshape radar capabilities. The mentality of 'it has never been done like this' no longer holds up as a valid reason to ignore new science and technology. The latest advances – whether they're more compact, cost-effective or use groundbreaking solid-state processing –

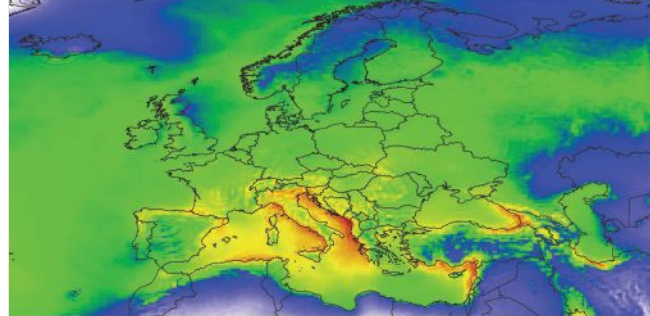
Radar band suitability



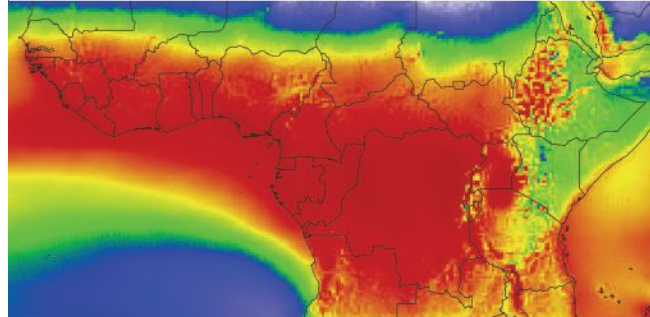
Marcos Massari, VP of business at Climatempo, in front of the Meteopress C-band radar deployed in Porto Alegre, serving the state of Rio Grande do Sul in Brazil with exceptional radar data



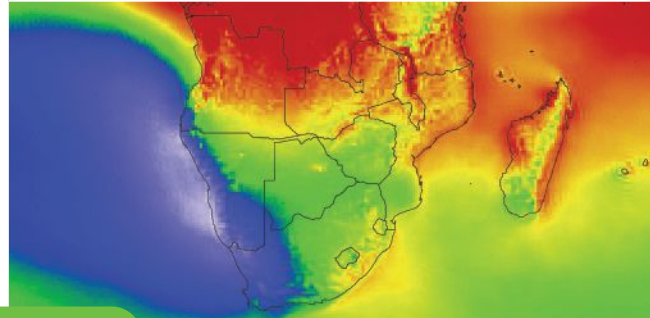
Europe



Central Africa



South Africa



have shown they can meet and often exceed the performance of traditional radar models. It's important to question long-standing assumptions and make decisions rooted in data, not just in convention. Embracing these advances can lead to more effective meteorological operations, enhanced forecasting accuracy and, ultimately, greater value to the communities these institutions serve.

Overview of radar bands and their suitability

In operational meteorology, three main radar bands are used – X-band, S-band and C-band – and their suitability is closely tied to a region's climate. X-band radars operate at higher frequencies (8-12GHz), providing excellent resolution. However, this frequency range is particularly susceptible to attenuation, meaning the signal weakens quickly as it encounters heavy rainfall or other obstructions. This can limit the radar's effective range, especially in regions with frequent, intense storms. Therefore, these radars are best suited to dry regions with sparse

QUICK EXPLAINER

Meteopress's model for radar band suitability uses ERA5-based climatology data from the years 2017-2023, incorporating key metrics such as rainfall intensity, convective available potential energy (CAPE) and cloudiness. The model's findings highlight that S-band radars are ideal for tropical regions and areas subject to intense convective activity; C-band radars are better suited to temperate zones with moderate storm activity; and X-band radars are effective in arid regions or for non-meteorological applications.

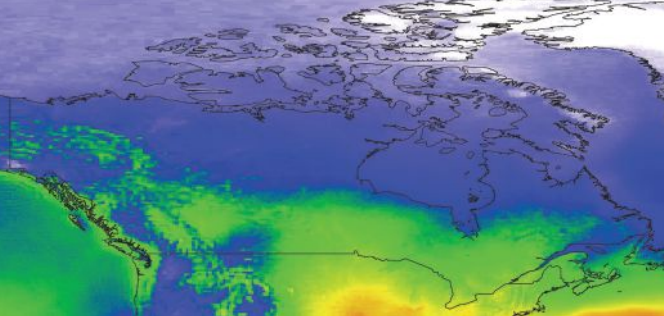
precipitation, such as deserts, where they can also be used for non-meteorological applications. In these areas, X-band radars can help track bird migration, monitor air traffic and even provide wind profile data from clear-air echoes.

The low attenuation properties of S-band radars (~3GHz), meanwhile, make them highly effective in regions with severe storms or tropical climates. S-band radars can accurately penetrate heavy rain, making them invaluable for areas prone

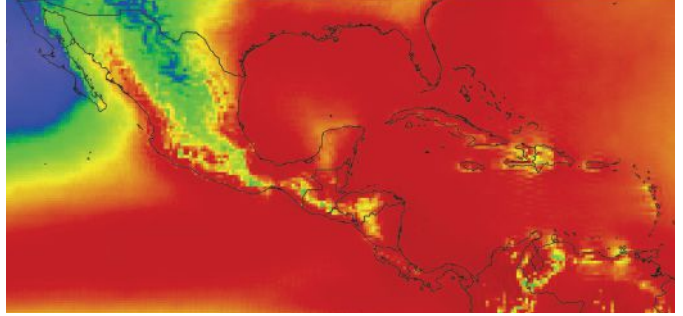
to convective storms, such as the USA, parts of India, southeastern China and the South Pacific Convergence Zone.

In these regions, S-band radars can provide clear, consistent data even in the most challenging conditions. However, traditional S-band radars used to be very costly to purchase, maintain and

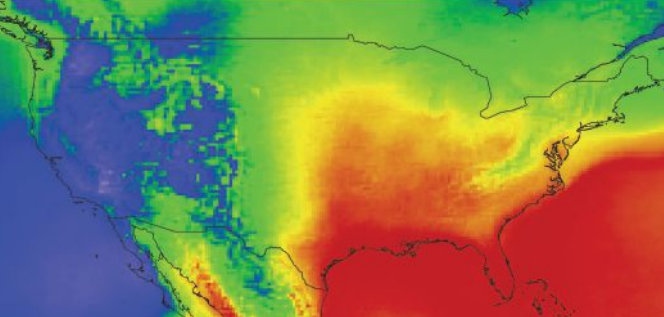
Canada



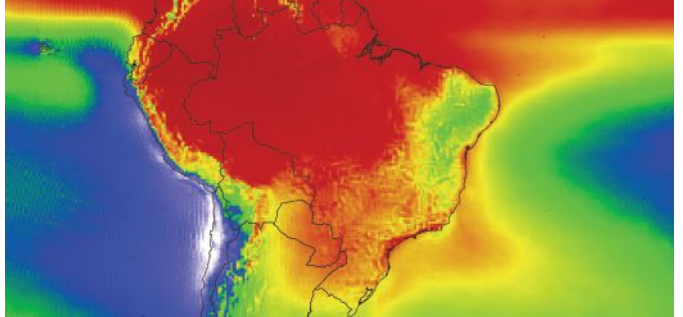
Central America



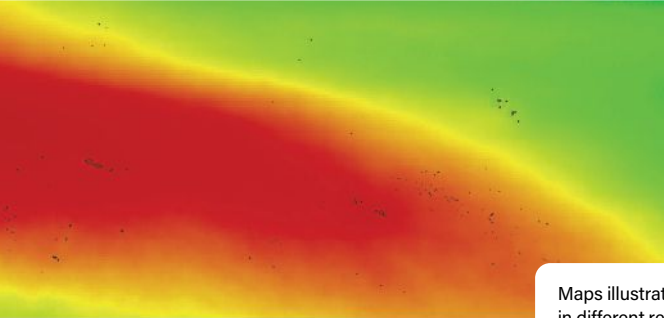
USA



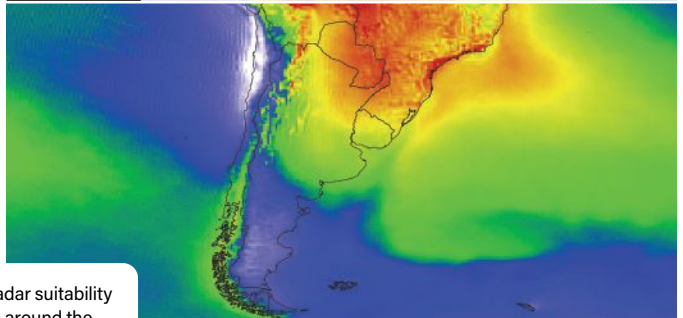
Brazil



Pacific



Argentina



Maps illustrating radar suitability in different regions around the world. Blue represent X-band, green C-band and red S-band

install, especially in remote areas where infrastructure needs are extensive.

Sitting between X-band and S-band in terms of frequency, C-band radars (~5GHz) offer a solid balance between attenuation and resolution. They are popular and perform adequately in regions with moderate climates, where extreme rainfall is less frequent. Countries with such climates, including much of Europe, New Zealand, Canada and parts of Australia, find C-band radars to be a cost-effective, high-performing option.

Advances in radar technology

Historically, the high price of C-band radars drove budget-conscious buyers toward more affordable X-band options, even when they weren't always ideal for the region's weather patterns. However, recent technological advances have reshaped the radar market globally, meaning that C-band radars can now be offered at a similar price to X-band radars. The same goes for the C-band versus S-band trade-off.

Meteopress's key innovations

Meteopress is one firm leading these technological advances. Its solid-state radar technology, for example, has reduced maintenance costs and enabled more efficient energy use in C-band radars. Solid-state technology is also affecting S-band systems, allowing radar installations in locations where traditional large, power-intensive setups would have been prohibitive.

Meanwhile, innovative algorithms in signal processing enable the use of smaller antennas without sacrificing performance. Traditionally, radar users were advised to use large antennas – up to 4m or more – for effective C-band operation. With these advances, C-band radars now perform well with smaller 2.4m or 3m dishes, which are easier to transport, install and maintain. Likewise, S-band radars can achieve higher resolution with

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// The best radar band for operational meteorology depends on a combination of climate, budget and long-term goals”

only a 4m dish, a substantial improvement over the 8.5m antennas previously considered essential.

These innovations mean that buyers can select radar options that meet their specific operational needs without feeling compelled to overspend or compromise on performance. This technological shift allows meteorological services to optimize their radar choices scientifically rather than solely based on traditional or budgetary constraints.

A practical guide to radar band selection

With the introduction of affordable C-band options and new solid-state capabilities, the radar selection landscape is no longer driven purely by cost.

Instead, it is now possible to prioritize regional weather demands, operational goals and long-term cost-effectiveness.

When looking for a new radar, there are several factors to consider. For areas prone to severe weather or cyclones, such as tropical regions, monsoon belts and parts of the USA, S-band remains the top choice due to its ability to penetrate heavy rainfall and provide accurate data during severe weather events. But an 8.5m dish is not necessarily required. With modern signal processing, just 4m can be enough.

For temperate zones with moderate to heavy seasonal precipitation, C-band is cost-effective, providing good performance without the need for extensive infrastructure.

And for arid or dry climates with minimal precipitation, such as deserts or high-altitude regions, X-band radars can serve effectively and may also contribute to other monitoring needs, such as air traffic and wildlife tracking.

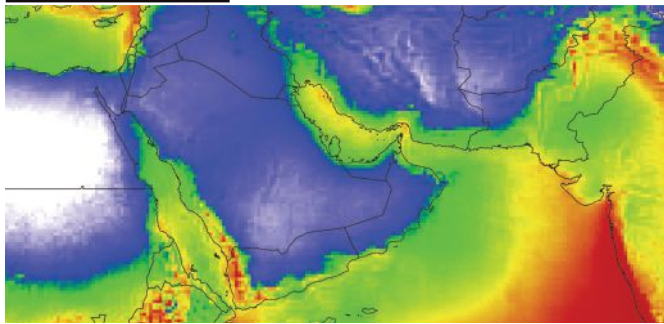
A scientific approach to choosing the right radar band for each region

Selecting a radar band is less about making trade-offs and more about aligning one's choice with budget, the region's meteorological needs and the latest technology available.

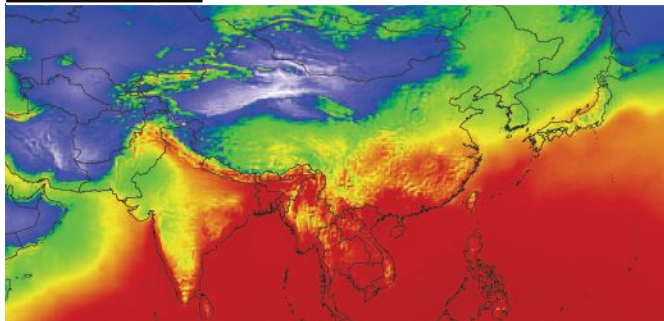
With innovations like Meteopress's solid-state technology and advanced signal processing algorithms, C-band radars are now affordable and highly capable, bridging the gap between X-band and S-band in cost and functionality.

S-band radars remain ideal for high-intensity weather zones, but smaller, more efficient setups mean they can be deployed in areas previously inaccessible due to cost or infrastructure demands.

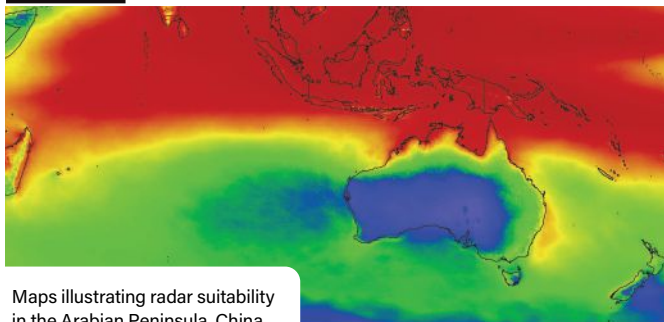
Arabian Peninsula



China and India



Australia



Maps illustrating radar suitability in the Arabian Peninsula, China and India, and Australia. Australia, for example, uses a combination of S-band (red) and C-band (green) radars around its northern and eastern coastlines

Ultimately, the best radar band for operational meteorology depends on a combination of climate, budget and long-term goals. By rethinking traditional paradigms and embracing scientific decision-making, meteorological organizations can make informed choices, selecting the radar that best meets their needs and supports reliable, high-quality data for years to come. It is disappointing to see radar tenders for tropical islands specifying X-band technology, as this choice not only misaligns with the region's intense weather patterns but also squanders public funds, effort and energy on a less effective solution.

Meteopress provides unbiased, complimentary consultancy to help determine the most suitable radar band for any location worldwide. ■

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