Wind energy developers understand the need to use climate reference data as part of the wind resource assessments that drive energy production estimates. This is because wind resource may rise and fall over the course of decades, due to longer-term fluctuations in the climate. The objective of climate reference data is to accurately reflect the future climatology; climate reference data can increase or decrease the long-term energy estimate by two or more percent. A reference of twenty or more years is generally recommended to accurately capture the climatology of a project location.

In the past, the wind energy industry largely relied on data from airports and other weather stations. This approach was imperfect because much of the historical wind data is often measured from 10 to 30 meters, nowhere near hub height, and may be very far away from the location of a project. The use of reanalysis data is now much more of an industry standard, and multiple high-quality reanalysis data sets are available for use in wind resource assessment.

One of the benefits of these reanalysis datasets is that they provide a consistent and global long-term reference going back at least 40 years into the past. Careful analysis of these datasets can reveal long-term trends that lead to speculation about how well the past can predict the future. However, determining the cause of long-term changes to wind speeds is challenging. Often, when a long-term trend exists, It is nearly impossible to establish if the trend will revert, become the new normal, or continue in the current direction.

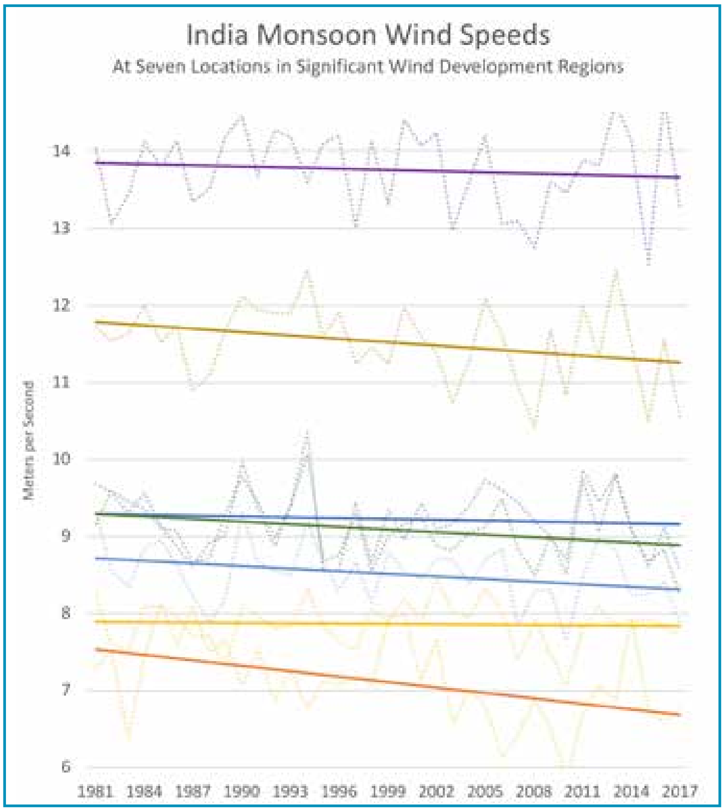
So, when we see things happen that don't seem normal — such as the multi-year shift shown in India during the monsoon season — we are tempted to adjust the way we use climate reference data. Simply put, we may say "The climate is changing, so we need to shorten the time period we use as a reference." This is what is happening in India, where a ten year long-term reference is now common.

There are two problems with this "climate reference haircut" approach. First, because of the way the industry calculates long-term energy, a shorter record increases the uncertainty assigned to the long-term energy estimate; and the uncertainty is a key metric for lenders. Second, it also risks not accurately reflecting the long-term average wind speed, which directly impacts the energy production calculations: using only the last 10 years may not provide a better estimate of the next 20 years.

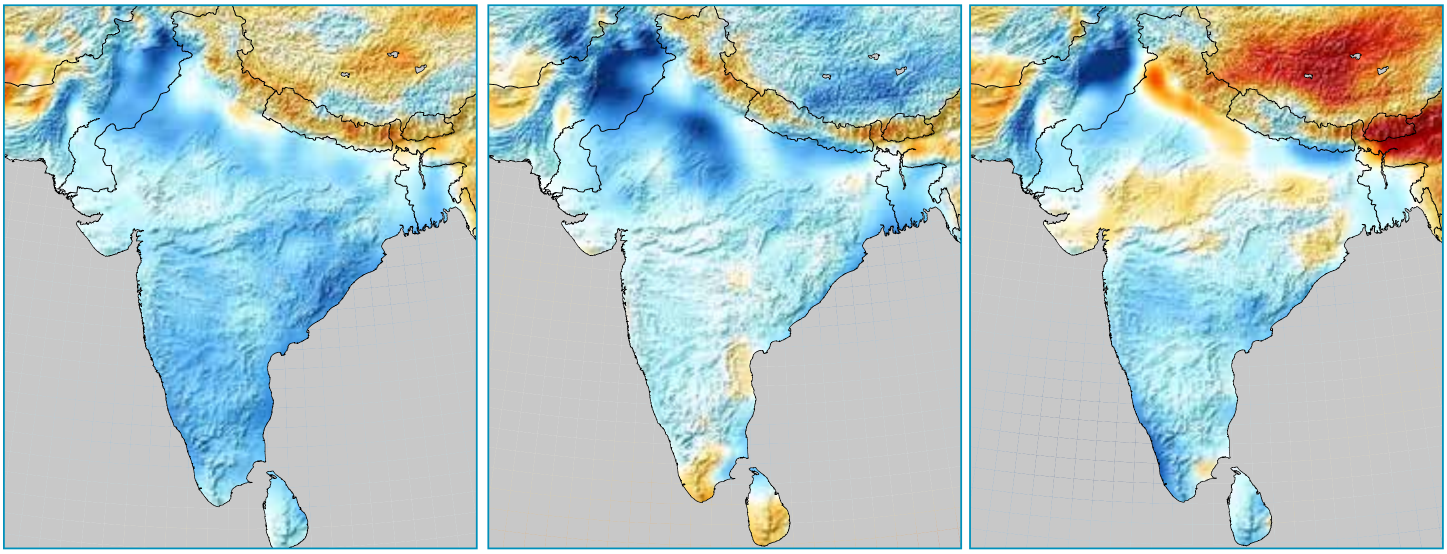
Vaisala's Energy Risk Framework uses an ensemble of reanalysis data as the basis of the long-term reference. (An ensemble is an average of data sets, weighted according to our expert knowledge). This enables Vaisala to compare the recent period with the long-term climate across multiple reanalysis data sets. The Energy Risk Framework calculates the likelihood that the recent period is consistent with the past. If the probability of reversion to the long-term mean is low, then a shorter reference is calculated and applied. The intent is to have as long a record as possible, while accepting that at times a shorter record is more appropriate. Vaisala continues to develop the Energy Risk Framework as part of its continuous development and validation process.

The maps included in this overview use one reanalysis data set, rather than an ensemble. They show departures from the "normal" wind speeds (the time period from 1980 to 2017). They provide a good starting point for anyone interested in investigating recent wind speed anomalies in India. For a more comprehensive analysis of any given site we would use an ensemble of reanalysis data sets, as applied in Vaisala's Wind Energy Due Diligence process.

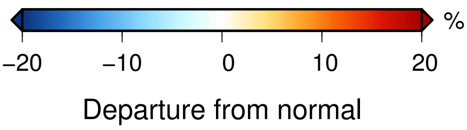
Long-term time series from seven locations in India where significant wind energy development has taken place were analyzed. The data was not corrected using actual energy generation or wind observations. There is a significant variance from location to location. The largest decline is in Rajasthan, where average monsoon wind speeds are down 11% over the period. The second largest decline were in Karnataka, Northern Tamil Nadu, and Northern Maharashtra, with declines between 4–5%. Locations in Gujarat, Southern Maharashrta, and Southern Tamil Nadu had only marginal declines of 1%.



Time series from India wind energy centers. States from top to bottom are; Tamil Nadu (South), Tamil Nadu (North), Maharashtra (South), Karnataka, Maharashtra (North), Gujarat, and Rajasthan.

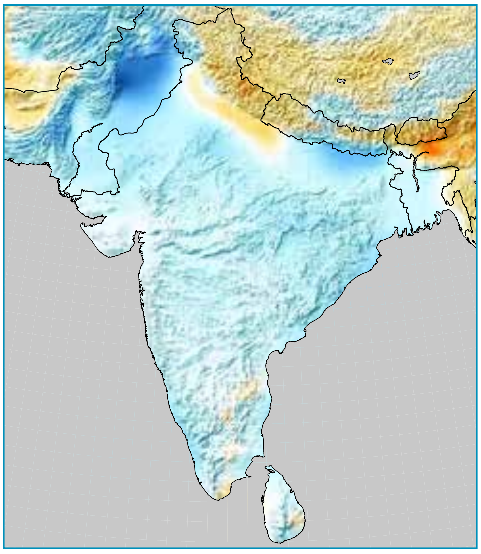


2017 — Monsoon Season | 2016 — Monsoon Season | 2015 — Monsoon Season

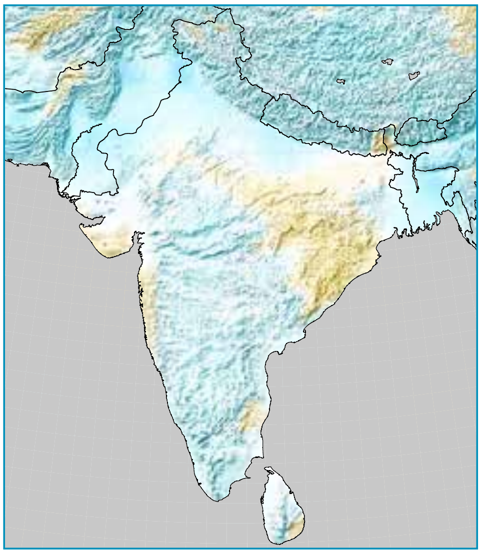


The past three India monsoons have been below the long-term average wind speed conditions. In India the monsoon period is the primary period of wind energy production. Under-performance during this period has a more substantial impact on annual energy production. Monsoon months are considered to be between June and September. Not all regions in India have experienced below average wind speeds. In 2017, the Gujarat and Madhya Pradesh states had average monsoon wind speeds close to their long-term averages. In the 2015 and 2016 monsoons, larger parts of India were average or slightly above average.

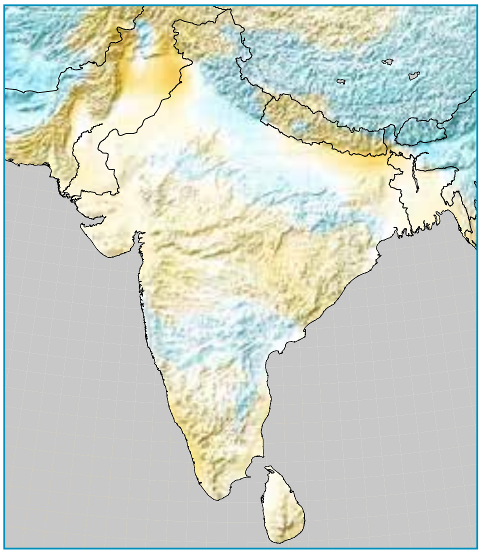
The India Wind Performance Maps show departure from average wind speeds. Vaisala produced these maps by comparing the period of record average wind speed to the long-term average conditions from the MERRA-2 re-analysis dataset.



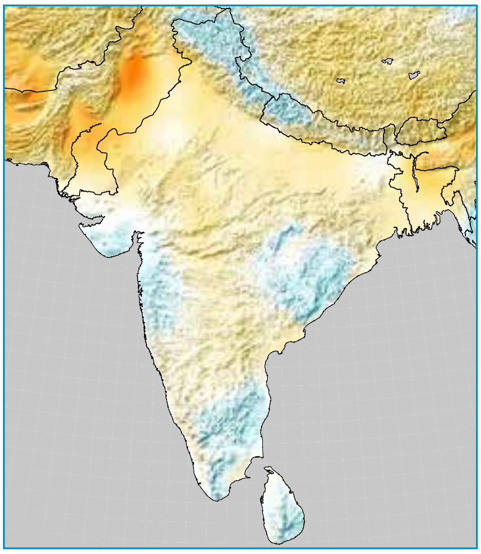
2010–2017 Monsoon Seasons



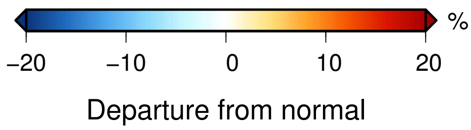
2000–2009 Monsoon Seasons



1990–1999 Monsoon Seasons



1980–1989 Monsoon Seasons



Decadal wind trends in India appear to be declining. Four decadal periods are analyzed; 1980–1989, 1990–1999, 2000–2009, 2010–2017. In most India locations, the twenty year period from 1980–1999 had higher average monsoon wind speeds. As modeled by the MERRA-2 reanalysis data set, many India locations have experienced a decadal shift in average monsoon winds speeds downwards. This is not true everywhere. Locations such as Gujarat appear to have more consistent long-term average wind speeds.

The India Wind Performance Maps show departure from average wind speeds. Vaisala produced these maps by comparing the period of record average wind speed to the long-term average conditions from the MERRA-2 re-analysis dataset.

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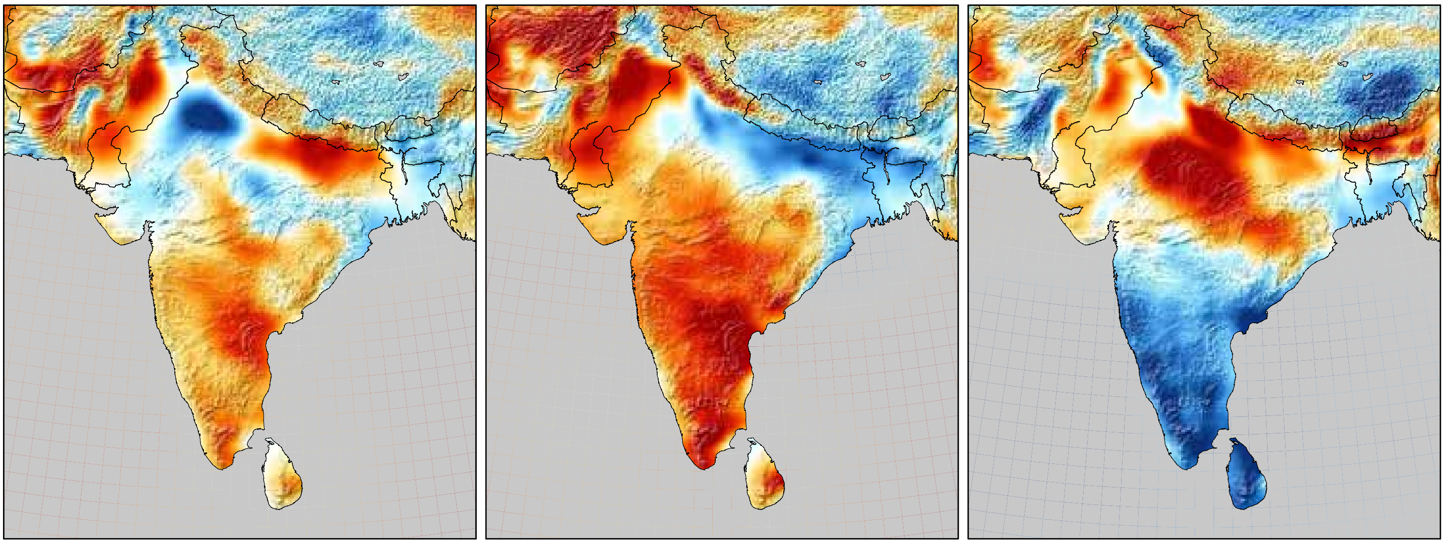
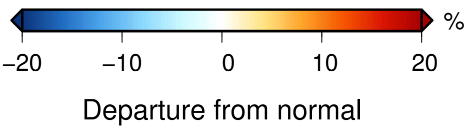


July 2018 | August 2018 | September 2018



The 2018 monsoon season broke the pattern established during the seasons of 2015, 2016, and 2017. Wind speeds throughout the south of India were especially high during the middle of the monsoon season in August. The higher-than-normal wind speeds will benefit wind farm production.

The India Wind Performance Maps show departure from average wind speeds. Vaisala produced these maps by comparing the period of record average wind speed to the long-term average conditions from the MERRA-2 re-analysis dataset.

Learn more at **www.vaisala.com/energy**

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