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Does the sun shine more brightly during a wind drought?

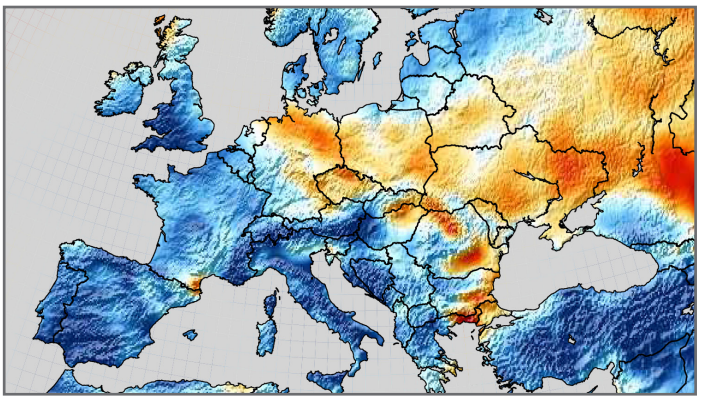
As a leader in wind and solar resource assessment for the renewable energy industry, Vaisala often is asked questions about overall weather patterns, especially when investment in wind and solar energy is at stake.

This July, heatwaves throughout Europe shrunk lakes, dried riverbeds, and turned lawns brown. The high temperatures also affected wind energy production — enough so that people began speaking of a "wind drought," and several major utilities reported lower-than-expected earnings.

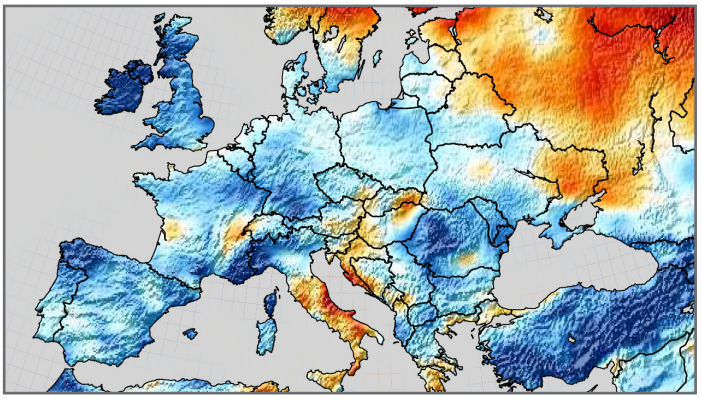
A look at wind anomaly data drawn from our 40-year database of wind speeds confirmed that winds across Europe throughout May, June, and July were almost uniformly lower than normal.

The high-pressure system which produced these conditions is expected to persist until October, October, so we took a look at what solar did during July to see if solar offset the lack of wind. While intuitively it should be sunny during a heat wave, it should also be sunny during the summer to begin with. So was solar near normal, or was it above normal by a significant margin to perhaps offset the wind deficit?

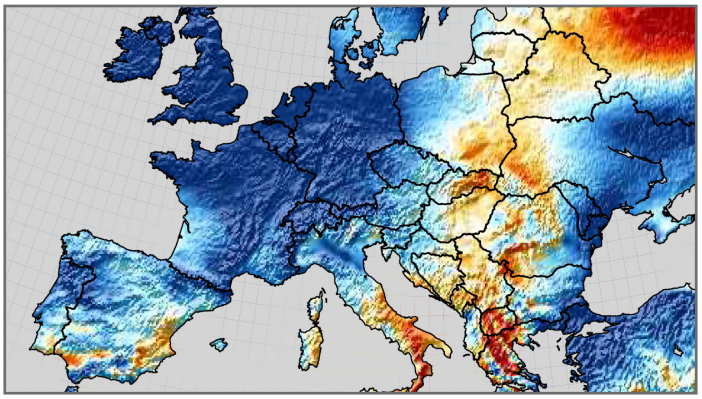
When we looked at data from our solar data set, we found that across Europe, throughout July 2018, when wind speeds were much lower than normal, solar irradiance was higher — much higher in some places.



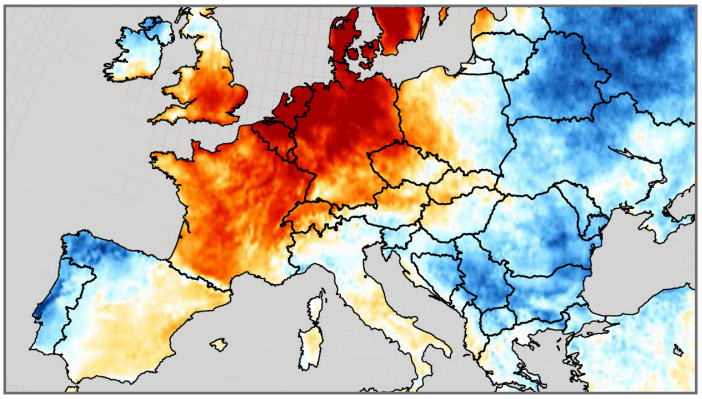
May 2018 wind speeds — departure from normal



June 2018 wind speeds — departure from normal

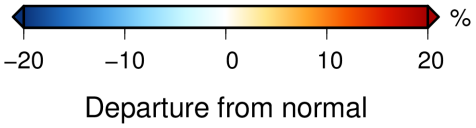


July 2018 wind speeds — departure from normal



July 2018 solar resource — departure from normal

The top three maps on this page display the departure from "normal" wind speeds at 100m, near the average hub-height of wind turbines, based on MERRA2 reanalysis data comparing 2018 to the average from 1980 through 2017. Blue areas indicate lower-than- normal wind speeds; orange areas indicate higher-than-normal wind speeds. The bottom map displays a similar departure from "normal" but for solar resource, specifically global horizontal irradiance (GHI).



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Can Solar Pick Up the Slack?

When considering solar and wind working together, most analysis is based on the understanding that it is windy during periods when the sun doesn't shine, say at night. Those short-term correlations are typically obvious, and can be understood with relatively short data records.

But what about from a resource perspective? If solar energy on average during a month is higher than usual when wind energy is lower, and vice versa, then perhaps solar and wind could backstop each other.

So solar was up when wind was down in July 2018. But is this a consistent pattern if we look at a larger number of years? If so, this could be helpful for creating a portfolio of renewable energy projects that is climate resilient.

Here is where weather data really shines, especially when you can easily visualize the data.

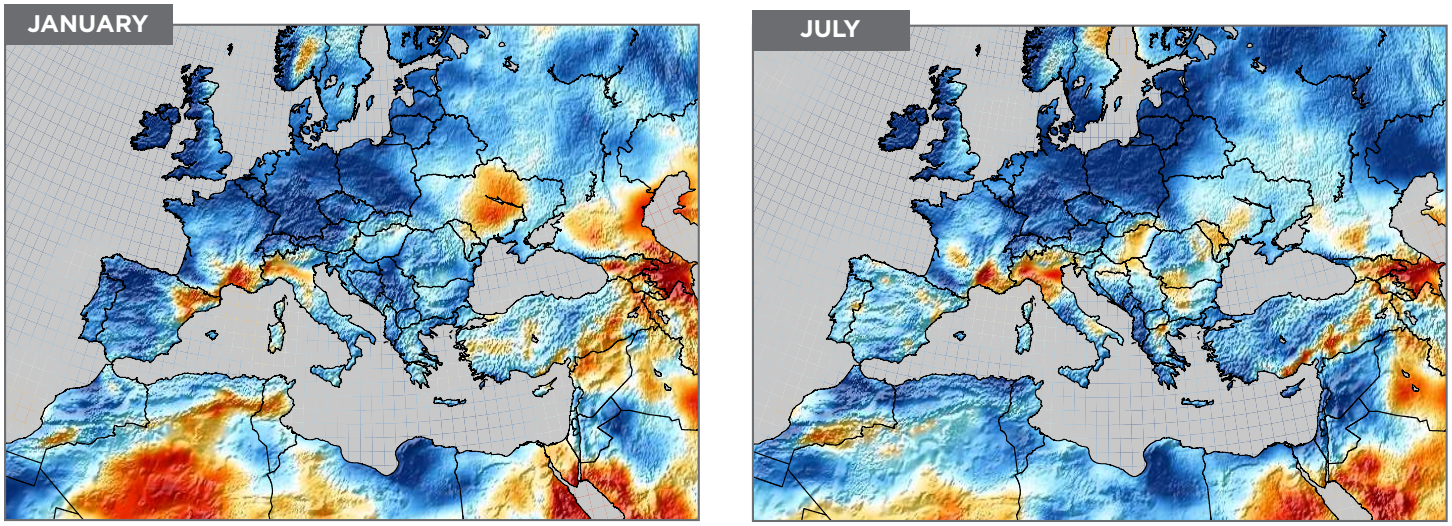
To investigate whether there is a positive or negative correlation between wind and solar energy departures from normal, we drew on our extensive wind and solar data sets, and produced "correlation maps" for each month of the year.

In the maps, blue shows areas of negative anomaly correlation — for example, where solar resource is high over an entire month when wind speed is low over that same month. Where the maps are orange that indicates positive anomaly correlation: solar and wind resource are both either high or low.

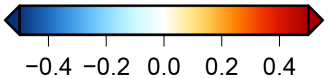
In every month, throughout most of Europe, there was a negative correlation between wind and solar. We're showing January and July here to illustrate.

Can solar pick up the slack when there is a wind drought? At most locations throughout Europe, the answer — based on nearly 40 years of wind and solar data — is yes.

Europe Wind-Solar Monthly Anomaly Correlations



These maps show correlations between wind and solar anomalies in Europe in January and July (analysis period from 1980 to 2017). Blue colors indicate areas of negative correlation: if one resource is lower than normal, the other is higher than normal. Orange colors indicate areas where if one resource is down for the month, the other is likely to be down as well. If the area is light colored or white, there is little or no correlation between the departures from normal of the two resources.



Correlation of Wind/Solar resource anomalies

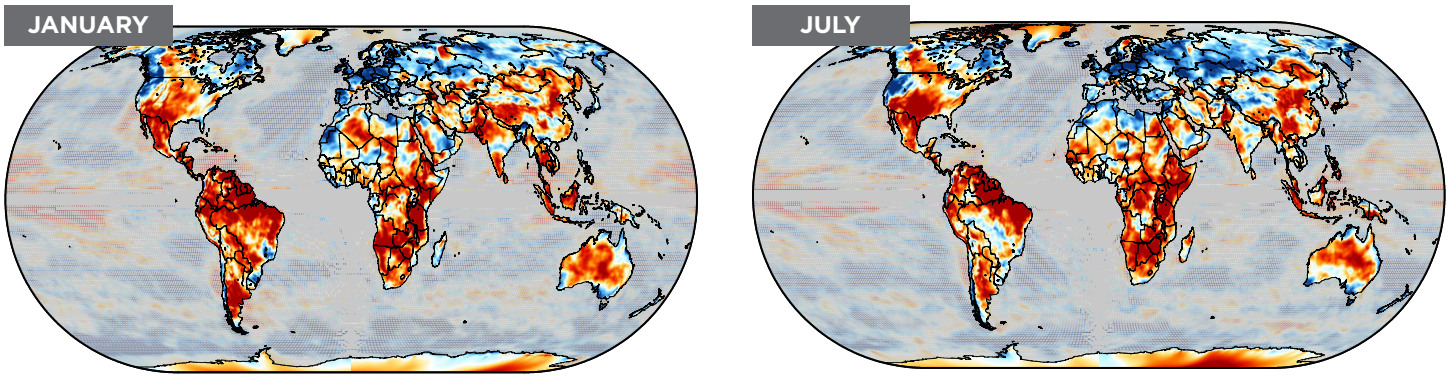
Global Correlation Analysis

So far, the evidence seems pretty positive that wind and solar can be used in a complementary way throughout much of Europe. What about the rest of the world?

To answer this question, we took the same approach with the global wind and solar data as we used to produce the correlation maps for Europe. The results were surprising.

Europe is one of the few regions of the world where solar and wind anomalies are consistently anti-correlated over large geographic regions. In the rest of the world it is much more hit or miss. There are definitely areas that have negative correlation, but there is a lot more orange (positive correlation) right next door. Again this has implications for anyone looking to create climate-resilient portfolios, and suggests that an approach using more localized and long term weather data is required to achieve any benefits of wind/solar technology diversity in these areas.

Global Wind-Solar Monthly Anomaly Correlations



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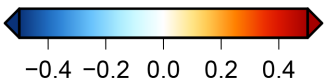

Correlation of Wind/Solar resource anomalies

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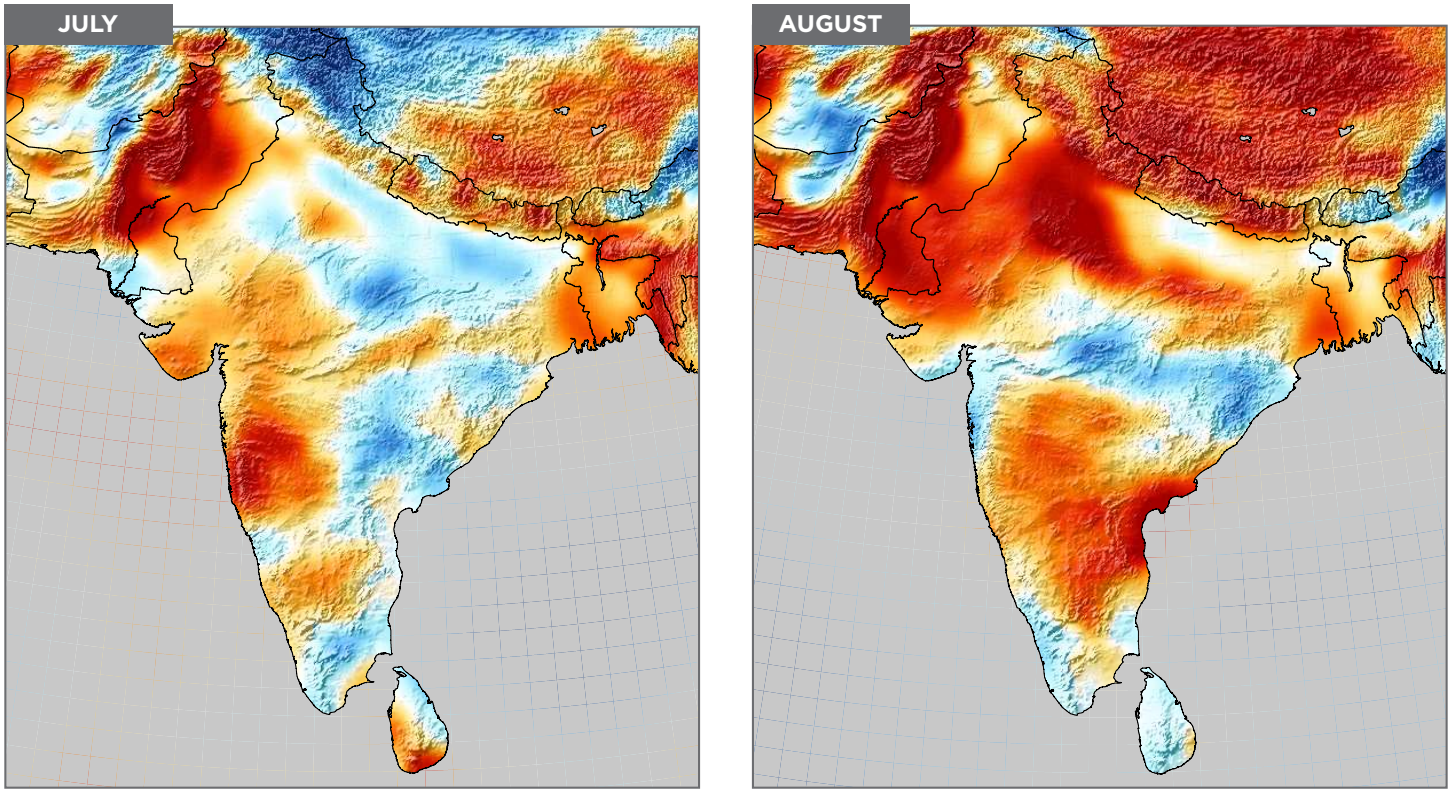
Indian Monsoon Season

We recently explored wind anomalies in India. Lower-than-expected winds during the last three monsoon seasons are significant because the monsoon season is typically the windiest of the year.

To make the most of limited transmission capacity, hybrid wind-solar developments are an active area in India, and Vaisala's resource assessment scientists are working with several customers to produce resource assessments of hybrid projects. Does solar energy have the capacity to fill in the gaps for wind if the monsoon season is below average? Or might it be sunnier and windier than average at the same time at a given location, resulting in an inability to get all that power onto the grid?

To answer these questions, we produced maps showing the 40-year average correlation between wind and solar anomalies for India during July and August. The answer varies by region. Just as we concluded when we looked at the recent low-wind monsoon seasons in India, it doesn't pay to draw blanket conclusions about wind and solar resource in India; because the anomaly correlations vary widely by region, a detailed analysis that incorporates many years (i.e. decades) of wind and solar data will produce the best hybrid system designs that minimize generation curtailment.

India Wind-Solar Monthly Anomaly Correlations



These maps show correlations between wind and solar anomalies in India in July and August (analysis period from 1980 to 2017). Blue colors indicate areas of negative correlation: if one resource is lower than normal, the other is higher than normal. Orange colors indicate areas where if one resource is down for the month, the other is likely to be down as well. If the area is light colored or white, there is little or no correlation between the two resources.

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