S2S4E
Climate Services for Clean Energy

CASE STUDY #6

WIND DROUGHT IN USA

First quarter 2015

BASIC FACTS

- **Area:** USA
- **Season:** winter
- **Year:** 2015
- **Forecast range:** seasonal
- **Main interest:** wind energy
- **Forecast variables:** wind speed and wind power capacity factor

This factsheet is based on S2S4E deliverable 4.1. To access the full report, please visit s2s4e.eu.

WHAT happened

Wind speeds were substantially below normal, reducing wind power generation. This reduction caused negative financial implications for wind farm owners in the western part of the country.

WHERE it affected

The wind drought especially affected states in the central U.S. and the west coast, such as Texas, Oklahoma, and Kansas, where the biggest wind farms are concentrated.

WHEN it occurred

The most significant part of the event occurred January through March 2015.

WHAT caused it

The high pressure and low winds conditions over North America were caused by a High North Pacific Mode status with a positive SST anomaly in the Western Tropical Pacific.

Analysis of the event

This case study notably marked an extreme climatic event in the United States. During the first months of 2015 (January–March), surface wind speeds were substantially below normal in most of the contiguous United States, which reduced substantially the power generation of the wind farms in the western part of the country (Texas, Oklahoma and Kansas in particular). These conditions had severe implications for wind farm owners who saw an important reduction in revenues, making difficult regular cash-flow operations.

This wind anomaly in the case study was measured in an area covering mid-western USA and Mexico during January to March 2015 (Figure 1). Anomaly maps for the period show that surface winds in the south-western part of North America were more than three standard deviations below the climatological average (Figure 2), with many weeks falling to extreme values under the 10th percentile (Figure 3). This continued and widespread wind drought was exceptionally rare when compared to the climatological records in the past years. The possibility that a climate forcing was driving those anomalies seemed very plausible in view of the substantial wind variations.

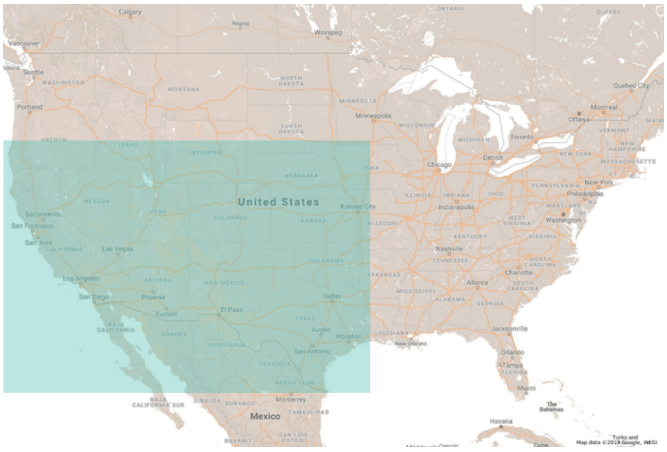

Figure 1. Study area.

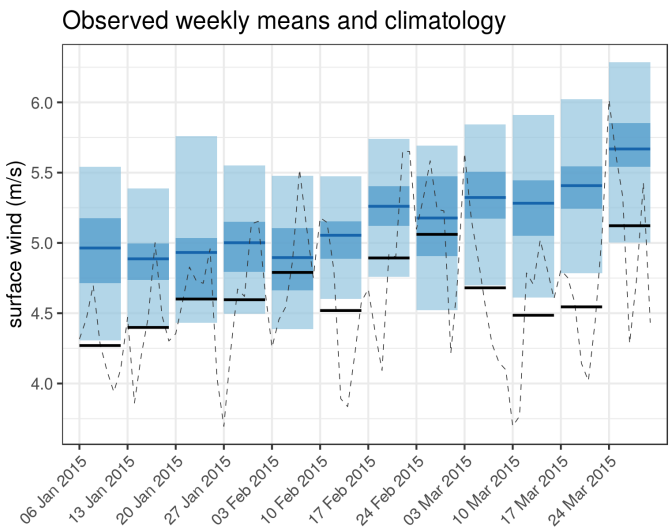

Figure 3. Observed weekly wind speed means for January through March 2015. ERA-Interim reanalysis.

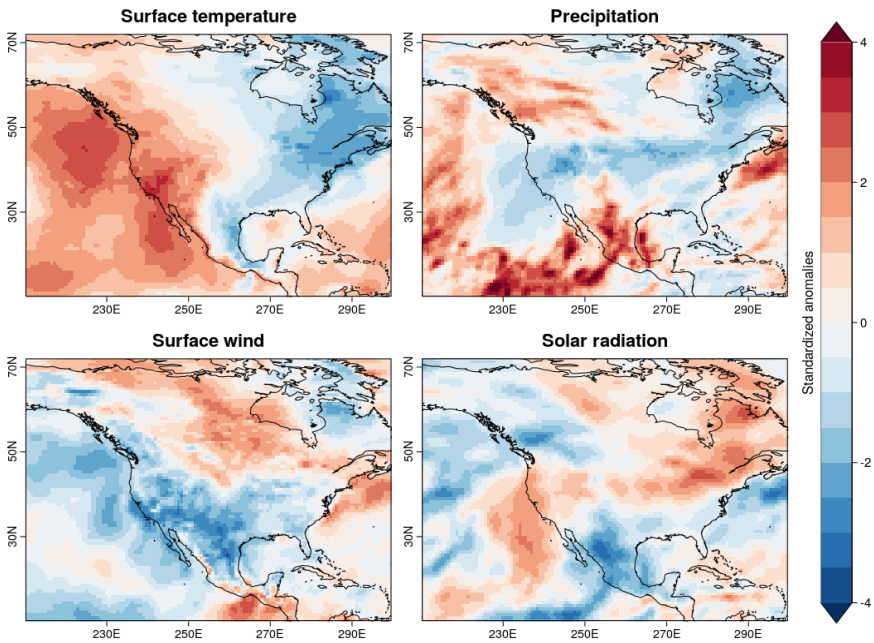

Figure 2. Standardized anomalies of temperature, precipitation, surface wind and solar radiation for January through March 2015. ERA-Interim reanalysis.

Available forecasts

S2S4E seasonal forecasts for wind speed and wind speed capacity factor (for IEC2 turbines) were produced for south-western United States using ECMWF SEAS5. The fRPSS values for wind speed and capacity factor forecasts (Table 1 and 2) were positive and fairly good, signifying high potential value of these forecasts for decision-making. For the three to one month lead times, the skill scores for wind speed were 0.35, 0.39 and 0.35. The IEC2 capacity factor skill scores were also high, with 0.23, 0.25 and 0.24 fRPSS values for the three to one month lead times.

For this specific wind drought event, the S2S4E seasonal forecasts for wind speed (Figure 4) were moderately able to predict the correct below normal tercile for all lead times, while the capacity factor forecasts for the IEC2 turbines (Figure 5) predicted the correct below normal tercile only at the three month lead time. For the three to one month lead times, the corresponding below normal probabilities for these forecasts were 50%, 45%, and 37% for wind speed and 42%, 33% and 29% for capacity factor IEC2.

Table 1. Probability skill scores for wind speed

Skill (Wind Speed)	Forecast lead time: 3 months (October)	2 months (November)	1 month (December)
RPSS	0.35	0.39	0.35
BSS P10	-0.07	-0.27	-0.16
BSS P90	0.10	0.04	0.07

Table 2. Probability skill scores for capacity factor for IEC2 turbines.

Skill (CF IEC2)	Forecast lead time: 3 months (October)	2 months (November)	1 month (December)
RPSS	0.23	0.25	0.24
BSS P10	-0.18	-0.23	-0.16
BSS P90	0.06	0.00	0.03

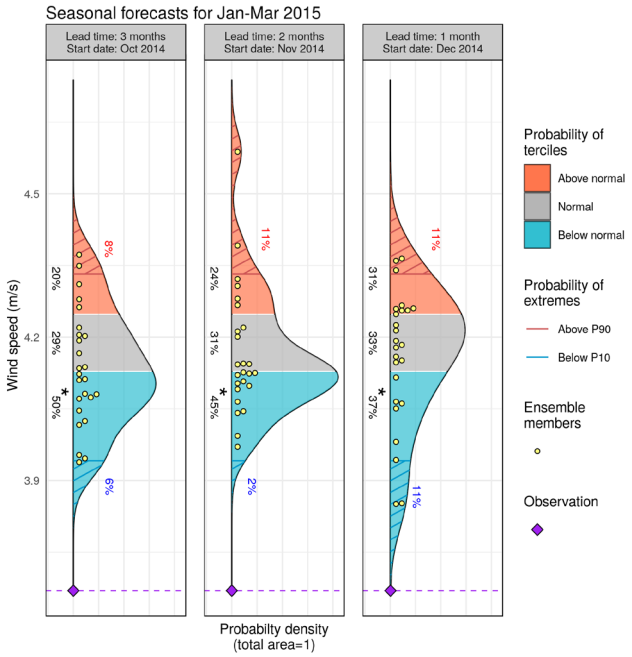

Figure 4. Seasonal forecasts for wind speed for January through March 2015. Issued three, two and one month in advance.

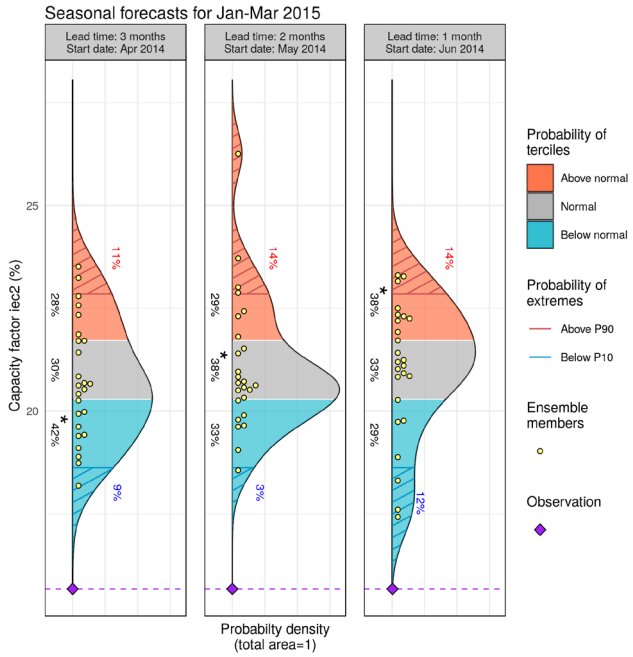

Figure 5. Seasonal forecasts for capacity factor IEC2 for January through March 2015. Issued three, two and one month in advance.

Drivers of the event

Although interannual variability of wind speeds in the region has been typically driven by El Niño Southern Oscillation (ENSO), this wind drought episode has been attributed to the North Pacific Mode (NPM) state, which reached its maximum historical value, while ENSO was only moderately positive (Figure 6).

High sea surface temperatures (SST) anomalies in the western tropical Pacific (WTP) produced enhanced convection and induced an atmospheric bridge process that caused the wind speed reductions in the United States. Numerical experiments with a climate model have proved that this teleconnection mechanism was key to trigger the event. For more information on the climate drivers of this event, see Lledó et al. (2018).

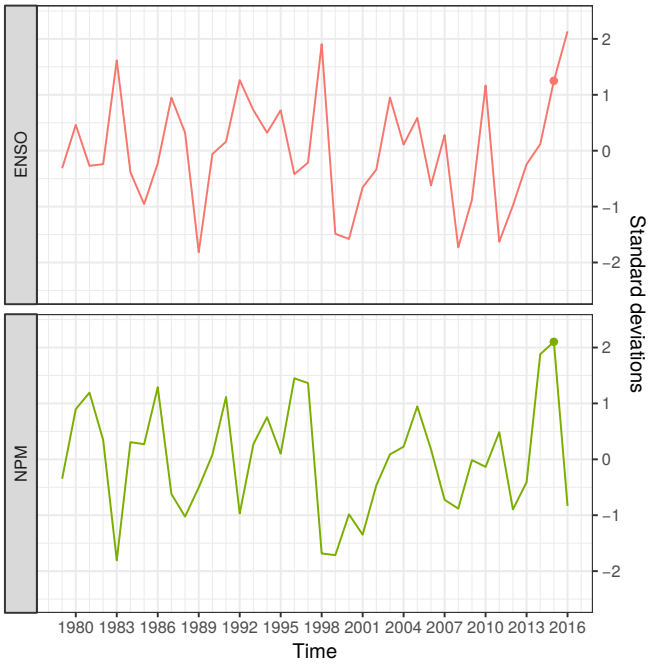

Figure 6. Historical evolution of the ENSO (top) and NPM status (bottom), January through March 2015.

Conclusions

Episodes of prolonged low wind speed (also known as wind droughts) can negatively affect the wind power industry. The fRPSS values of the S2S4E forecasts demonstrate high positive skill for the region and time period analysed in this case study. This means that S2S4E forecasts are better than climatology and have potential to anticipate wind droughts a few months in advance.

For the 2015 wind drought studied, the S2S4E forecasts moderately predicted the correct below normal tercile for wind speeds, while the capacity factor forecasts predicted the correct below normal tercile only at the three month lead time.

According to the climate drivers assessment, this region is sensitive to the impact of teleconnections arising in the tropical Pacific, such as ENSO or NPM.

References:

Lledó, Ll., Bellprat, O., Doblas-Reyes, F. J., & Soret, A. (2018). Investigating the effects of Pacific Sea Surface Temperatures on the Wind Drought of 2015 Over the United States. Journal of Geophysical Research: Atmospheres, 123, 4837– 4849. doi:10.1029/2017JD028019.

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