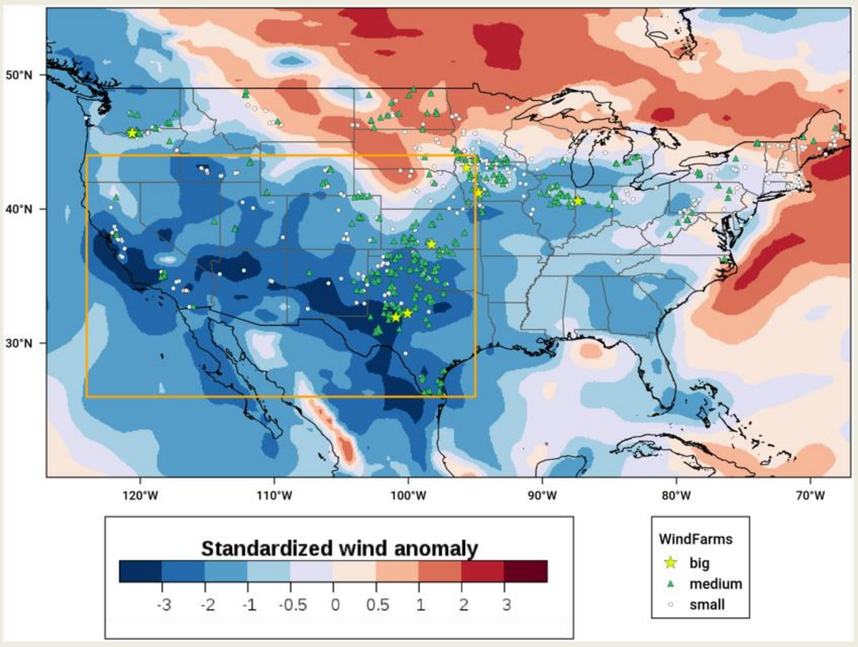
Wind drought episodes in the US and Europe

Llorenç Lledó[1] (llledo@bsc.es) & Albert Soret[1].

[1] Earth Sciences Department, Barcelona Supercomputing Center (BSC), Spain

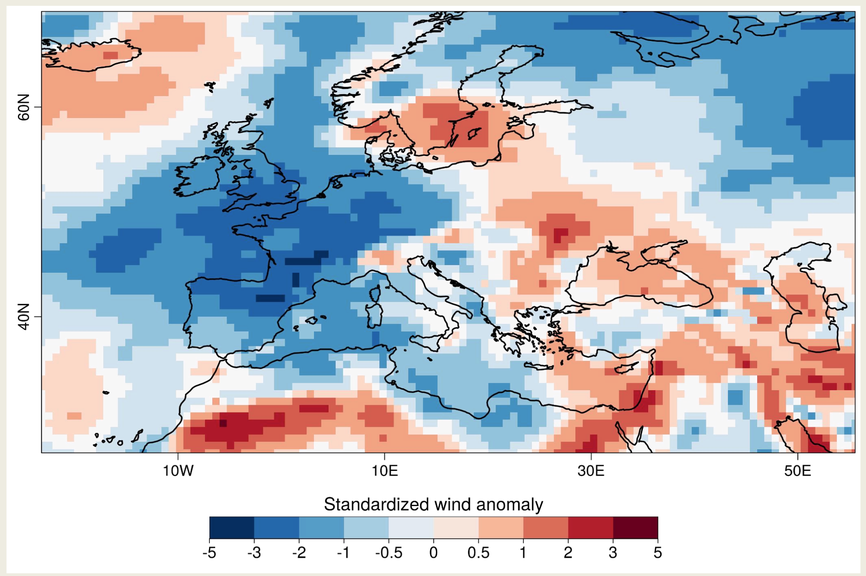
1. US wind drought – JFM 2015

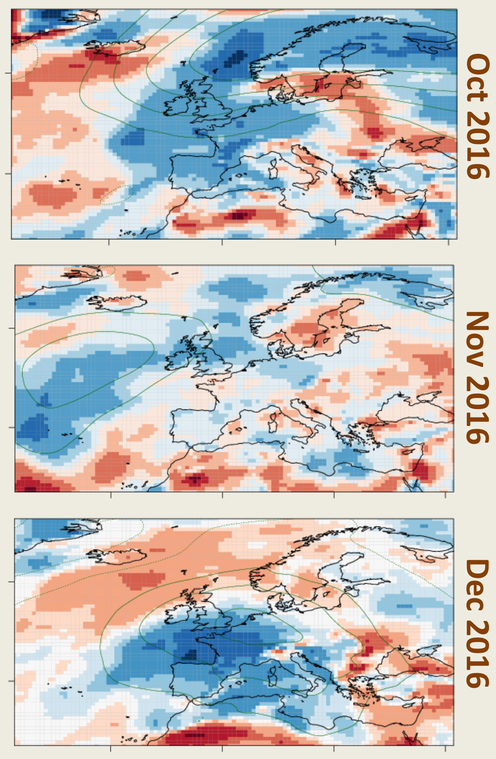
During the first quarter of 2015 the United States experienced a widespread and extended episode of low surface wind speeds. This episode had a strong impact on wind power generation. Some wind farms did not generate enough cash for their steady payments, and the value of wind farm assets decreased.



2. Europe wind drought – OND 2016

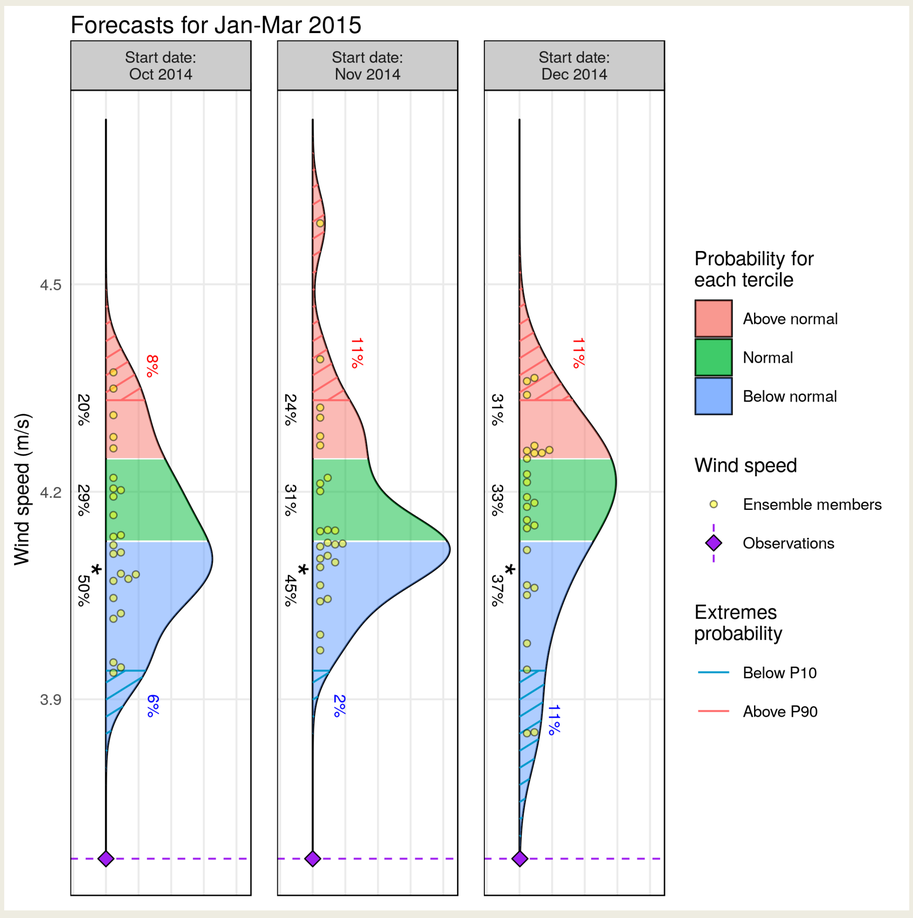
During three months in a row an outstanding high pressure system affected the circulation in Europe. Winds were more than three standard deviations below the climatological mean in some parts of France and Spain. Wind power generation was highly reduced in France, UK, Germany and Spain.





3. Can we anticipate these anomalies?

1) Bias adjust and calibrate ECMWF System5 probabilistic forecasts
2) Dress ensemble members and draw a pdf
3) Compute probabilities for terciles and extremes



- Probability for lower tercile is 50% three months in advance
- But probability for lower decile does not anticipate an extreme event

4. What caused those episodes?

These episodes impact society, raising questions:

- Why is this happening?
- When will winds revert back to normal?
- Is this due to climate change?

Looking for answers only in the atmosphere:

- Very bad luck (atmospheric variability)

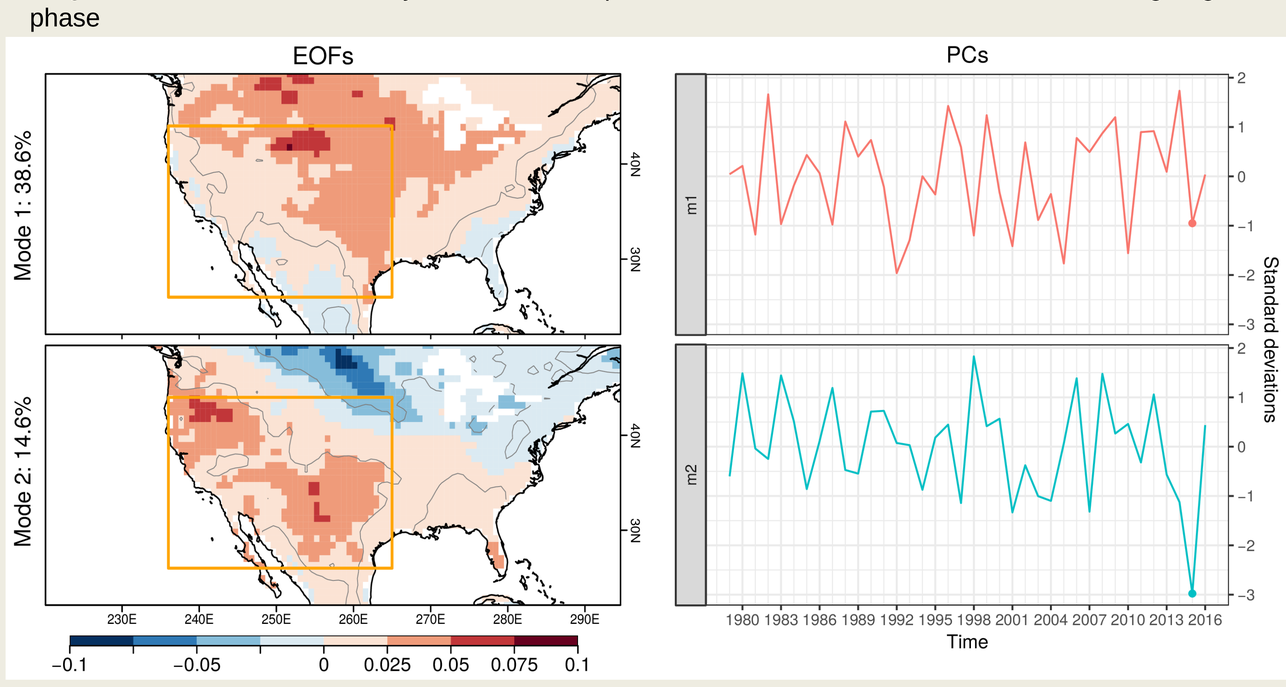
Looking for answers in the whole Earth System:

- A slowly evolving earth system component might be forcing the atmosphere

5. Wind speed variability in JFM in North America

We analyze surface wind variability through an EOF analysis

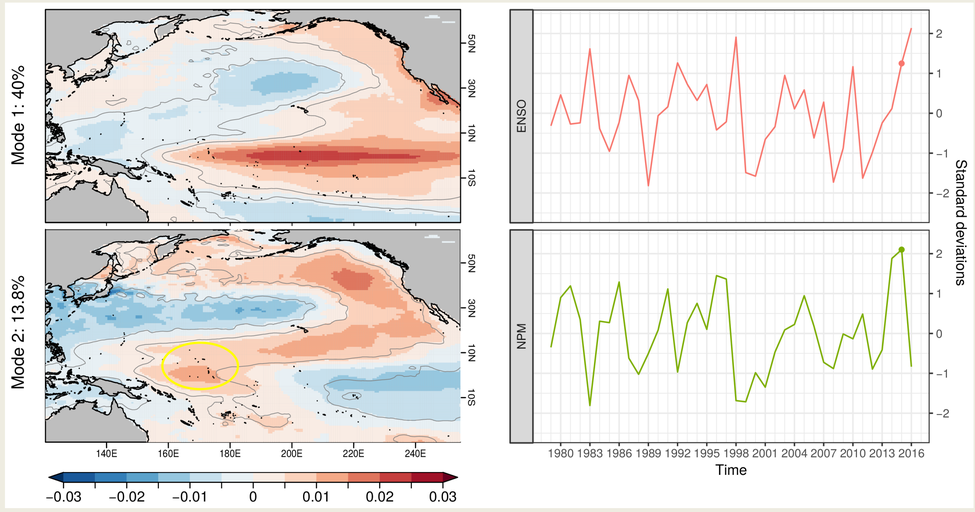
- In Q1 2015 the second variability mode of wind speed over North America was in an outstanding negative phase



6. SST variability in JFM in the Pacific Ocean

We analyze Pacific SST variability through another EOF analysis

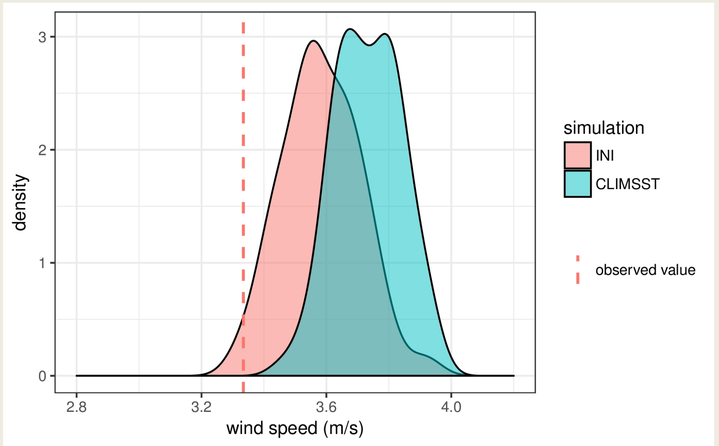
- In Q1 2015 the North Pacific Mode (NPM) was in a highly positive phase
- A statistically significant correlation between NPM and wind PC2 is found (R=-0.39)
- Higher correlation with PC2 is obtained using western tropical Pacific SSTs (R=-0.56)



7. Proving causation with EC-Earth

An Earth System model (EC-Earth) was run with different configurations to understand the role of Pacific SSTs in forcing the wind in the US:

- Three-month runs starting on 1st January 2015 and covering JFM with 100 ensemble members
- Atmosphere initialized with observed state on 1st Jan
- SST set to:
  1. INI: observed SSTs for Q1 2015
  2. CLIMSST: climatological SSTs

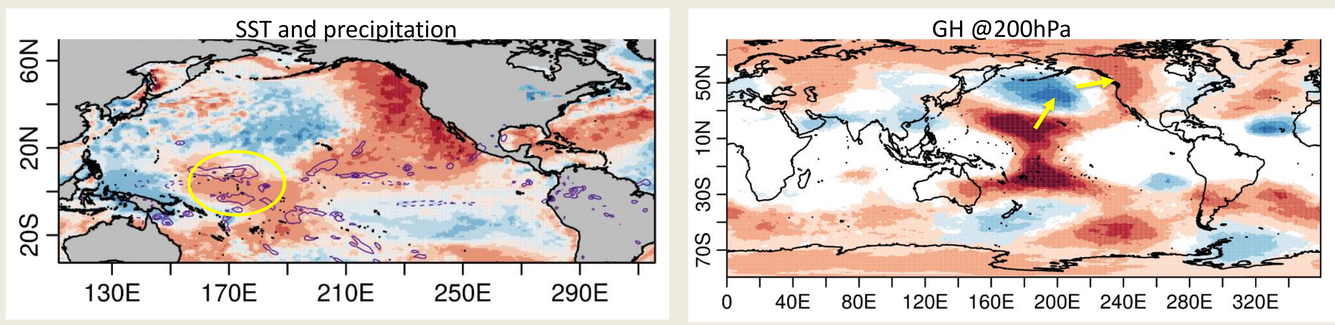


Results:
The distribution is shifted to lower winds when using the observed SSTs as forcing.

Under climatological SSTs the event would be very unlikely.

8. Unveiling physical mechanism

High SSTs in western tropical pacific drive enhanced convection. Upward flow produces divergence at 200hPa and a Rossby wave train propagates to North America resulting in persistent low winds



Conclusions

- The US wind drought of 2015 was forced by high SSTs in the western tropical Pacific
- Revealing the forcing mechanisms for case studies that impacted society is important in many aspects: it facilitates that users understand how and why seasonal predictions are made possible; it makes the forecasts more credible; and it can highlight physical processes that should be improved in the modeling systems.

References

Lledó, Ll. et al. (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. https://doi.org/10.1029/2017JD028019

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