Climate conditions associated with low wind power production and high electricity demand events in France

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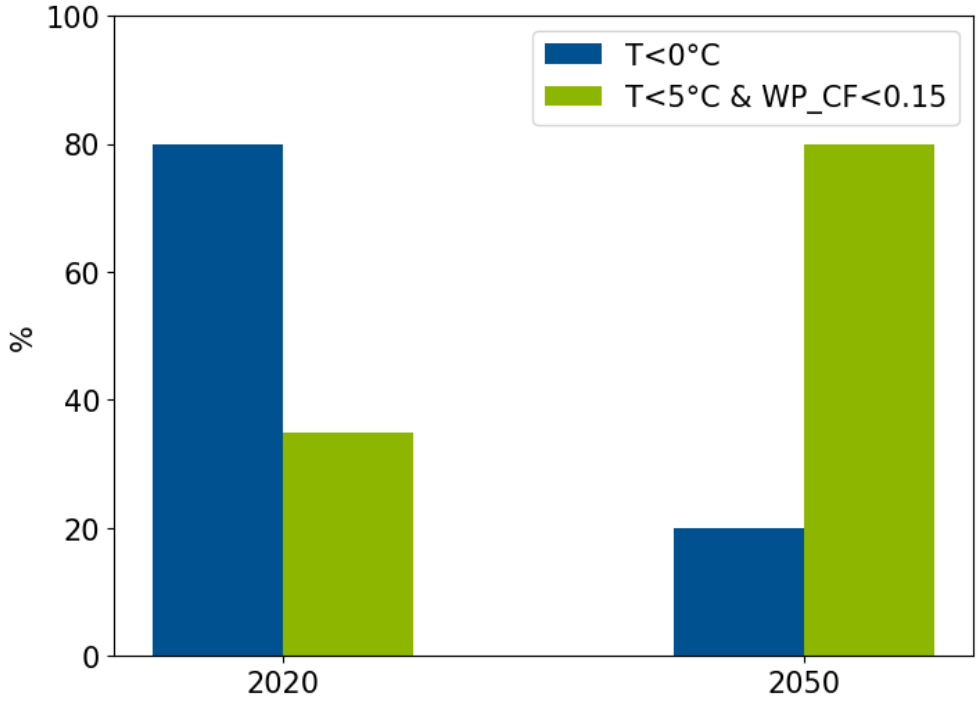
Evolution of climate risks on the electricity supply-demand balance

- Share of renewables is intended to increase :
  - ➢ Electricity supply + sensitive to climate variability.



Share of critical situations for the supply-demand balance for 2 climate conditions. Adapted from « Energy pathways to 2050 » report from RTE.

- Climate conditions associated with a high risk of electricity demand > supply days shift from cold days (T<0°C) today to days with low temperatures and wind speed (T<5°C & wind power CF<15%) in 2050.

Scientific questions

- What is the temporal evolution of compound events over 1940-2022 in France ?

- What are the circulation regimes associated with compound events ?

Method – Temperature indicator

Data :

- ERA5 reanalysis data : daily surface temperature (at 2m, t2m) for Nov, Dec, Jan, Feb of 1940-2022 at 32 French cities.

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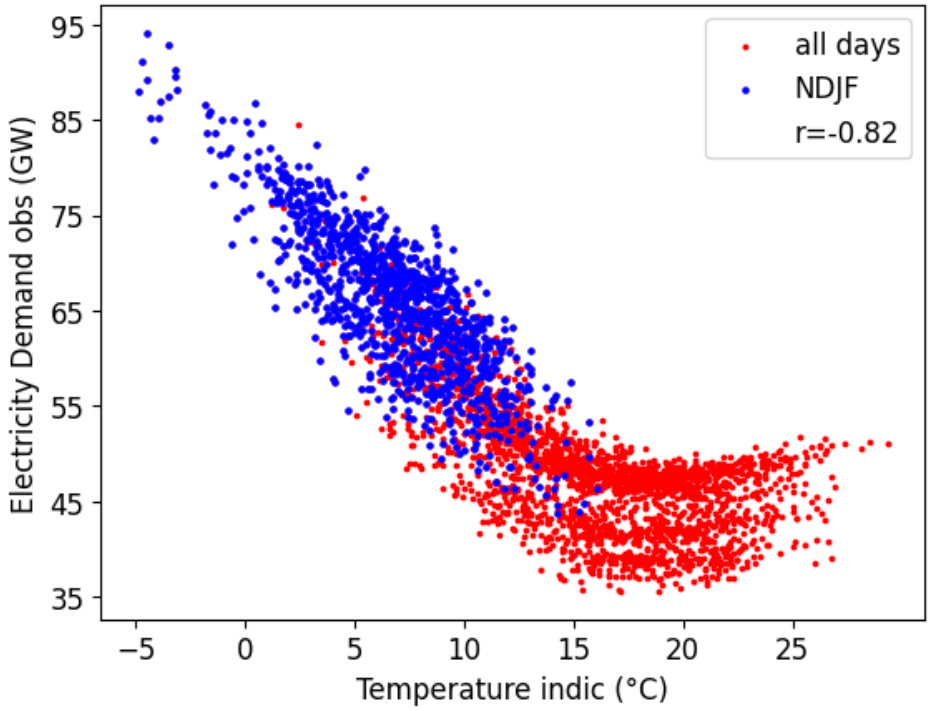
Validation :

- Electricity demand observation 2012-2020 for France (from RTE's eco2mix database).



Daily observed electricity demand vs. temperature indicator for 2012-2020.

Method – wind power indicator

Data :

- ERA5 reanalysis data : hourly 100-m wind speed for Nov, Dec, Jan, Feb of 1940-2022.
- Parameters of French onshore windfarms (Location, hub height, power, power curve) from windpower.net database

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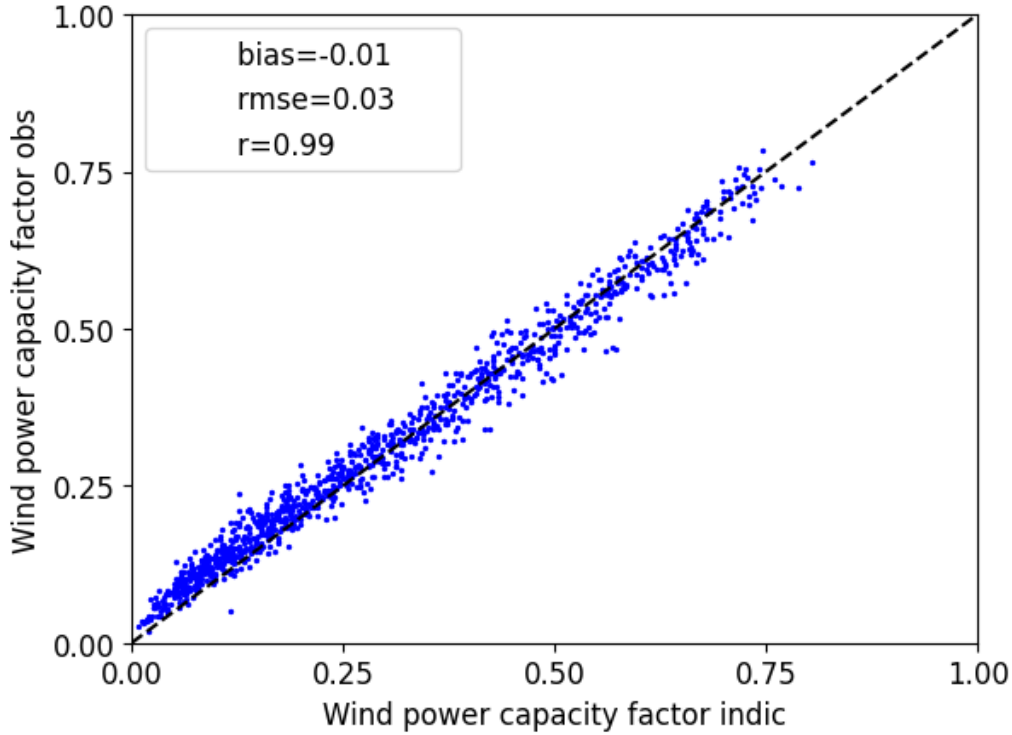
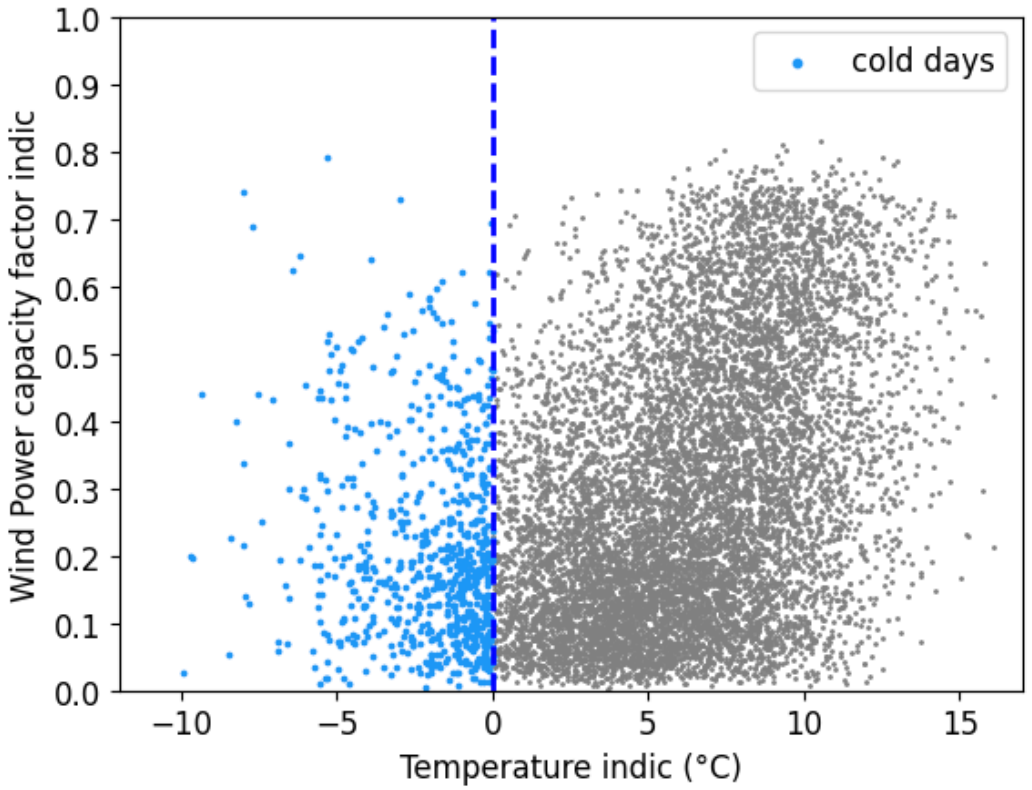


Daily observed wind capacity factor *vs. our indicator for 2012-2020.*

Method - Identification of cold, wind drought and compound days

Cold days :

- Temperature indicator < 0°C
- 11 days / extended winter on average over 1941-2022

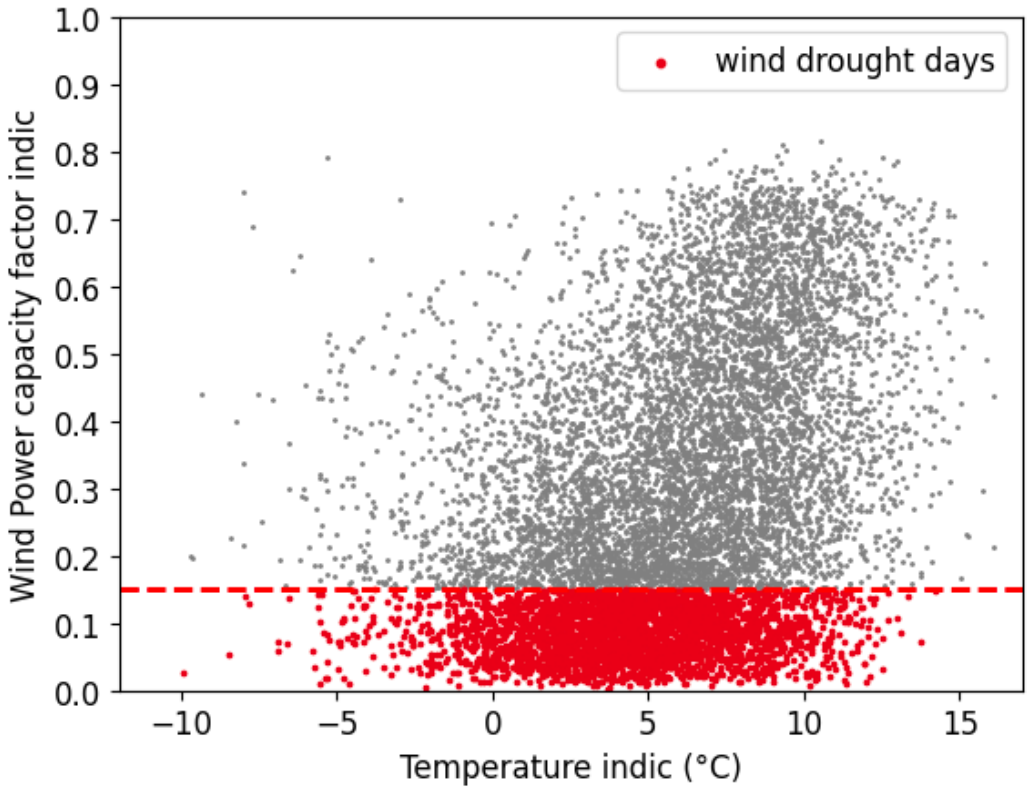


Daily Wind Power capacity factor vs. electricity demand indicator for extended winter of 1941-2022.

Method - Identification of cold, wind drought and compound days

Wind drought days :

- Wind power capacity factor indicator < 0.15
- 26 days / extended winter on average over 1941-2022



Daily Wind Power capacity factor vs. electricity demand indicator for extended winter of 1941-2022.

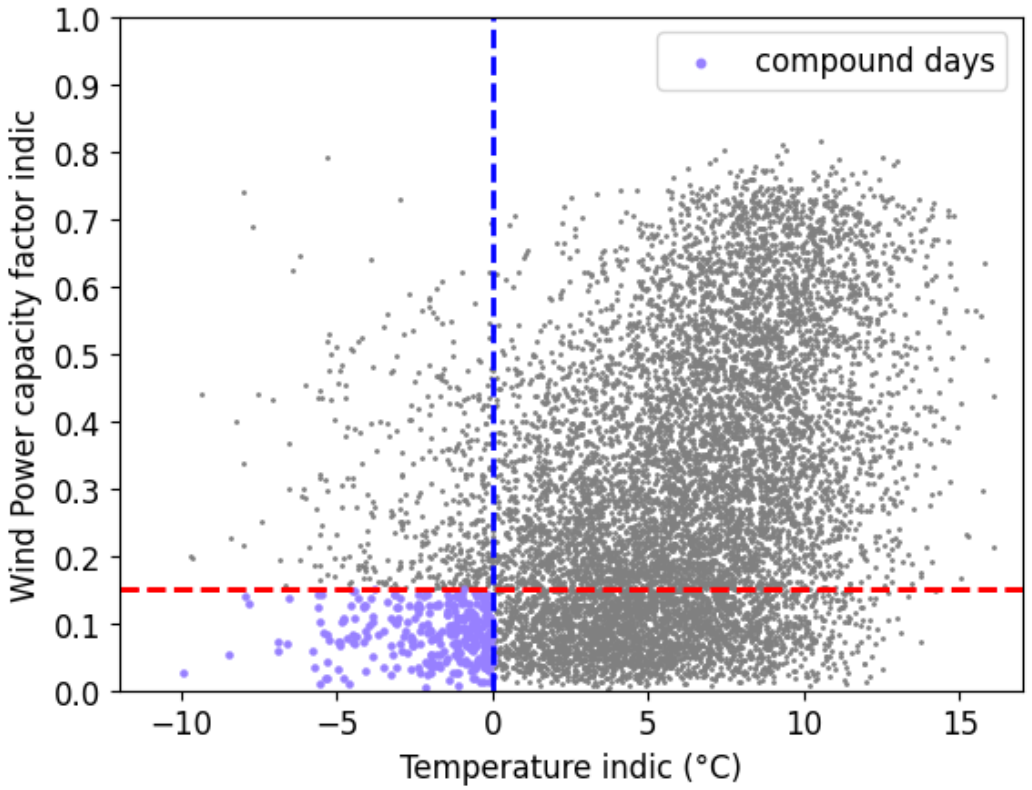
Method - Identification of cold, wind drought and compound days

Compound days :

- (Temperature indicator <0°C)

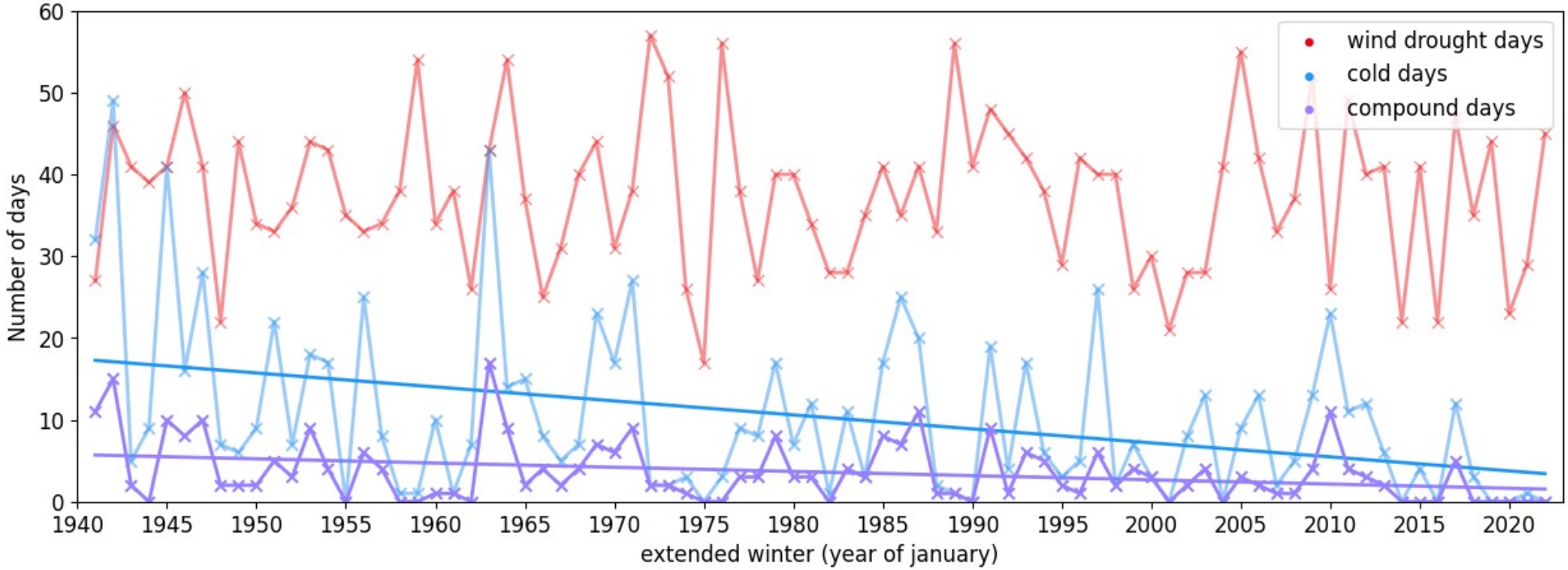
& (Wind power capacity factor indicator <0.15)

- 3 days / extended winter on average over 1941-2022



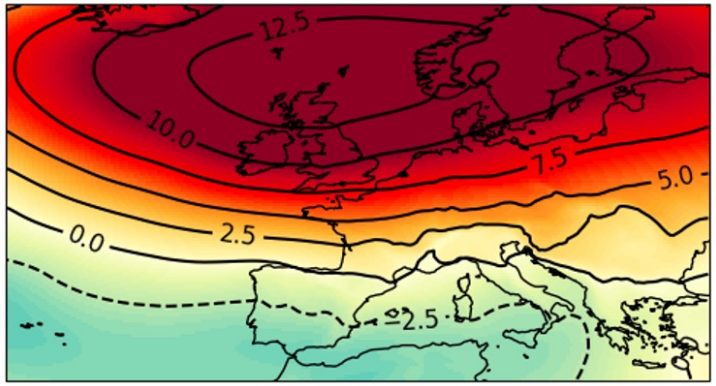
Daily Wind Power capacity factor vs. electricity demand indicator for extended winter of 1941-2022.

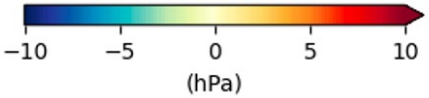
Evolution of the occurence of wind drought, cold and compound days over extended winter of 1941-2022.

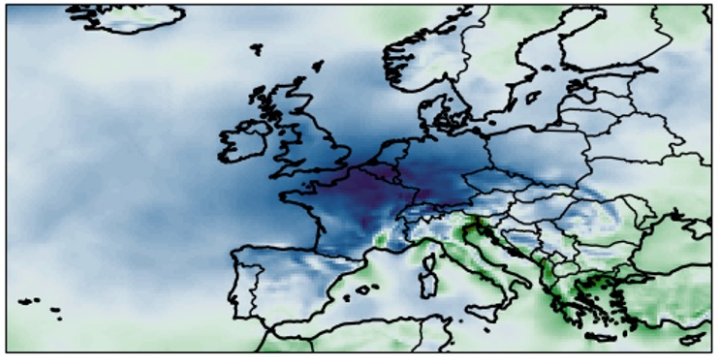


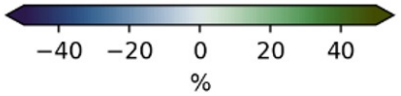
- Decreasing number of cold and compound days per extended winter for 1941-2022.

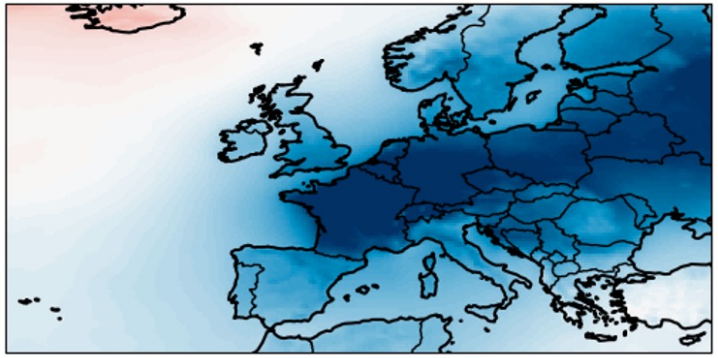
Average circulation and surface conditions for compound days

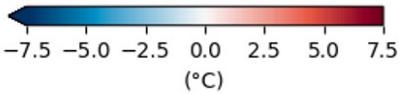












Composite of ERA5 (a) SLP anomaly (b) 100-m wind speed relative anomaly (c) surface temperature anomaly (c) for compound events over 1980-2022 period.

Circulation regimes for wind drought days

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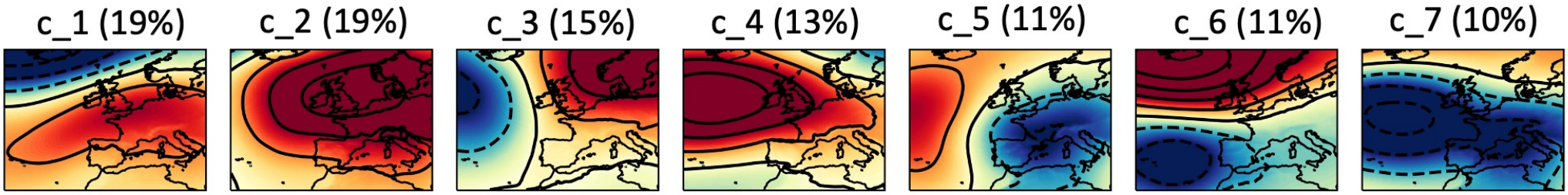
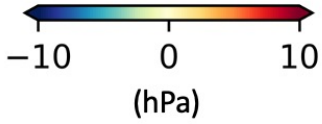
- Parameters of K-Means :
  - Classification domains (« North Atlantic », « Western Europe », « France »)
  - number of regimes ($2 \leq n \leq 15$)

  ➢ Find the set of parameters that minimize the metric $\mathrm{M} = \frac{\sigma_{intra-regime}(Electricity\_Demand)}{\sigma_{inter-regime}(Electricity\_Demand)}$

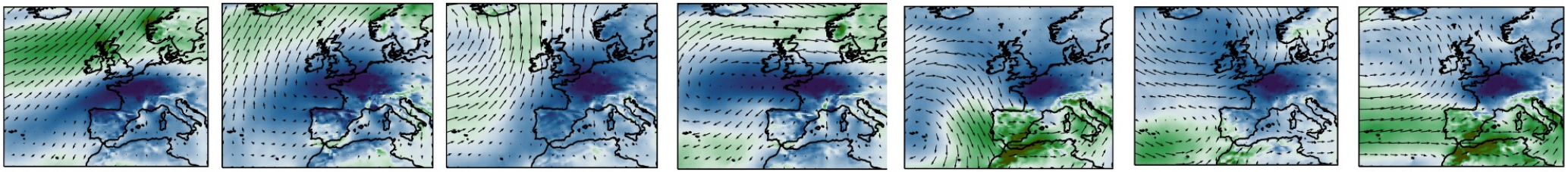
  ✓ Parameters chosen : 7 regimes & domain « Western Europe ».

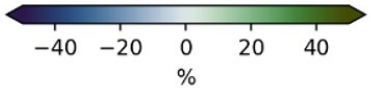
Circulation regimes for wind drought days





Composite of sea-level pressure anomaly for each circulation regimes.





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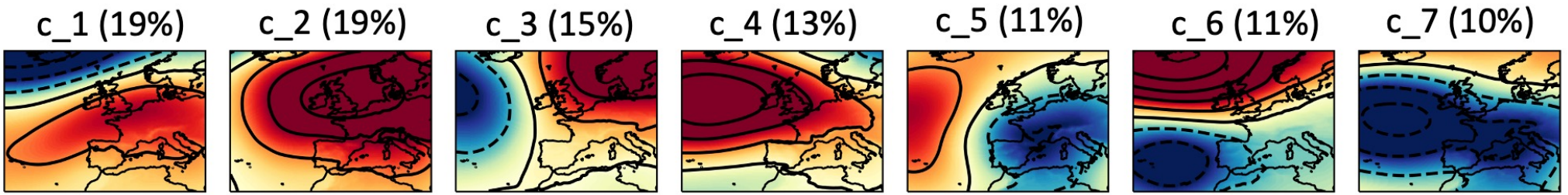
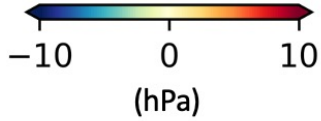
Surface temperature associated with circulation regimes for wind drought days





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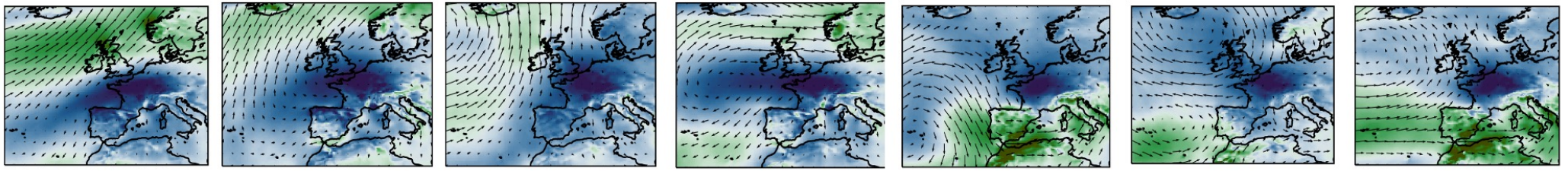

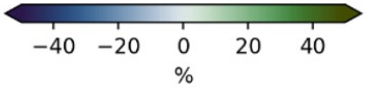

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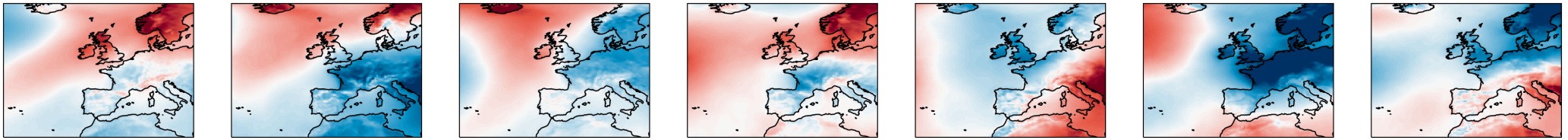

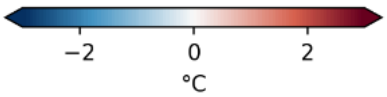

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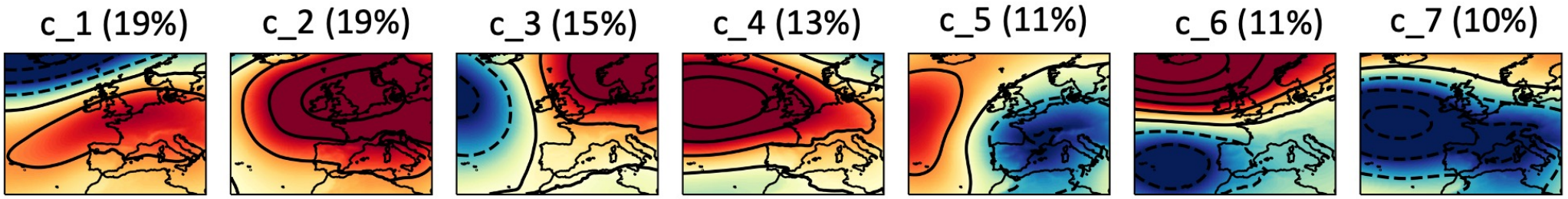
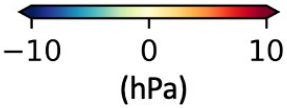
Circulation regimes for wind drought days associated with compound days





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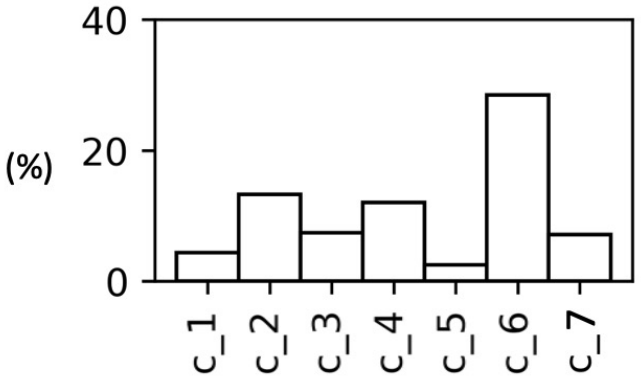
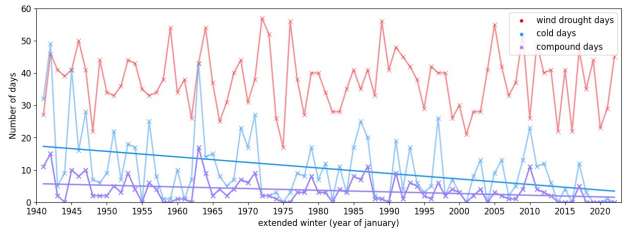


Proportion of compound events in each circulation regimes (%)

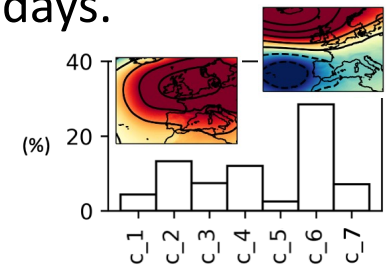
- Circulation regimes c_2 and c_6 are associated with higher risks of compound days.

Conclusions and perspectives



Conclusions :

- Decreasing number of cold and compound days per extended winter.
- Circulation regimes that resembles to NAO- and Scandinavian blocking *Weather regimes* are associated with higher proportion of compound days.



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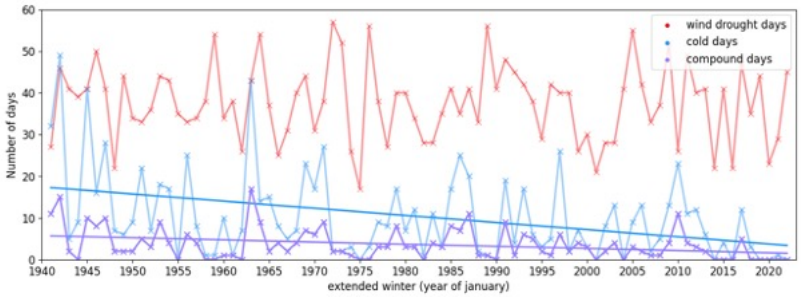

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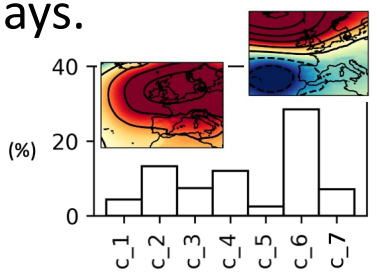

Perspectives :

- Evaluation of climate models on their representation of these circulations regimes.
- Evolution of these circulation regimes during the 21th century in climate projections.