

Review on: Weather pattern dynamics over Western Europe under climate change: Predictability, Information Entropy and Production

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General

This study considers the atmosphere as a nonequilibrium steady state system and applies methods published by Gaspard (2004) to determine predictability and irreversibility by the information entropy in observational and simulated data. The author uses block entropies for the forward and the time reversed block entropy in time series describing the North Atlantic/West European weather. The time evolution is described as a coarse-grained sequence of visited boxes. The predictability is assessed by the forward entropy and the entropy production by the irreversibility due to time reversal asymmetry.

The data are Großwetterlagen in the Eastern North Atlantic/Western Europe sector, which had been extracted in observations and scenario simulations. The daily time series are reduced by clustering of the patterns to 3, 6 and 8 time series. The observational time period is 1850-2019, and the simulated data is for 1900-2100. As the numerical effort for the joint probabilities is enormous, the 30 patterns had to be drastically reduced to 3, 6 and 8. Furthermore, the block lengths had to be reduced to two, to calculate the entropy S_2 . Thus, the present study is at the border of computational feasibility.

The study is insightful and relevant, although somehow preliminary, mostly due to computation restrictions. The agreement with previous studies hints at a reproducible core of results. The author should try to respond to the concerns, and if possible, less costly analyses might be added.

Specific Comments

I have several concerns, mostly on the use of Großwetterlagen and the nonstationarities in the data (mentioned in line 199).

- 1) **Großwetterlagen:** Großwetterlagen are certainly useful and have their merits in synoptics, but do they form a complete basis in state space? Do they depend on the domain similar to EOFs? Is a comparison with other sets meaningful? A short list of the selected Großwetterlagen patterns and the clusters would be useful.
- 2) **S_2 in the 3-pattern (Fig. 2):** For the 3-pattern the forward and backward entropies are $S_2^R=S_2$, hence there is no information entropy production in this basis. What does that mean for the choice of patterns? Is it possible to determine the entropy production independent of the basis?
- 3) **Anthropogenic climate change since 1860:** Global warming started early. Is it possible to find a similar behavior in the 21st century, hence a common imprint of global warming?

- 4) **Natural low-frequency variability:** Is the sea surface temperature relevant for the frequencies of the patterns in Fig. 2?
- 5) **Decrease of S_2 during 1850-1900:** Is the strong decrease of S_2 in Fig. 2 a hint for an overlooked nonstationarity?

Minor/Typos

Line 10: is?

Lines 149-154: the paragraph could be clearer, is $n=7$?

Figure 3 caption: length of words, n ?

Figures 4,5: a legend would be useful.