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A Practical Approach to Prediction of Geomagnetic Series

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A practical approach to prediction of geomagnetic series

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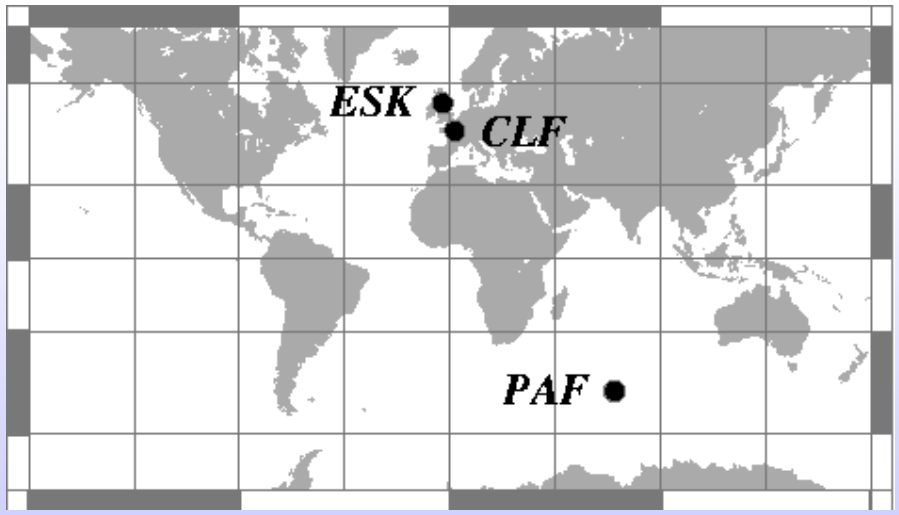
Can we predict the extreme geomagnetic events entirely from the knowledge of magnetic series?

To investigate this problem we have compared unusually long series of the magnetic vector differential at different locations computed with different resolution, from daily to minute.

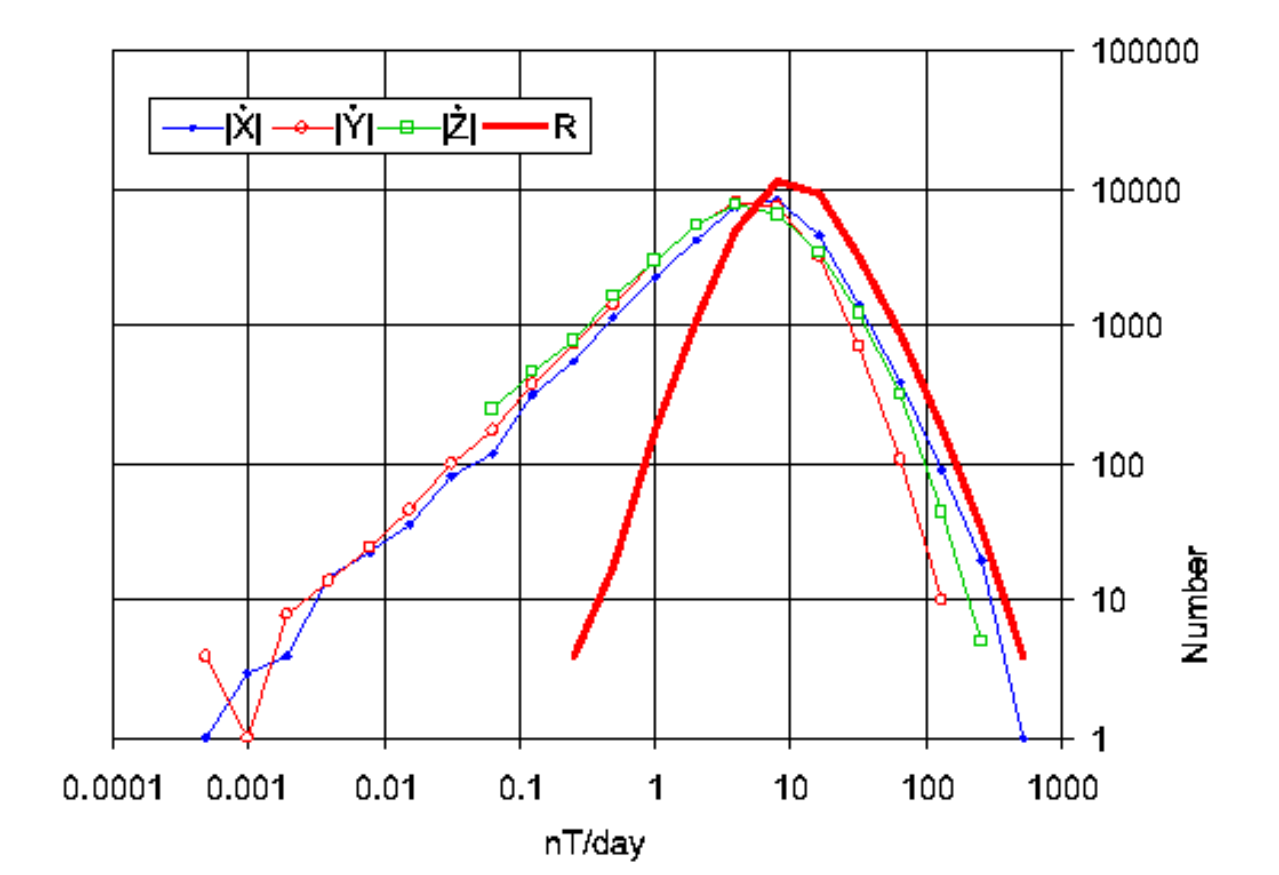
$$\mathbf{var\ |\dot{B}|} = \mathbf{R}$$



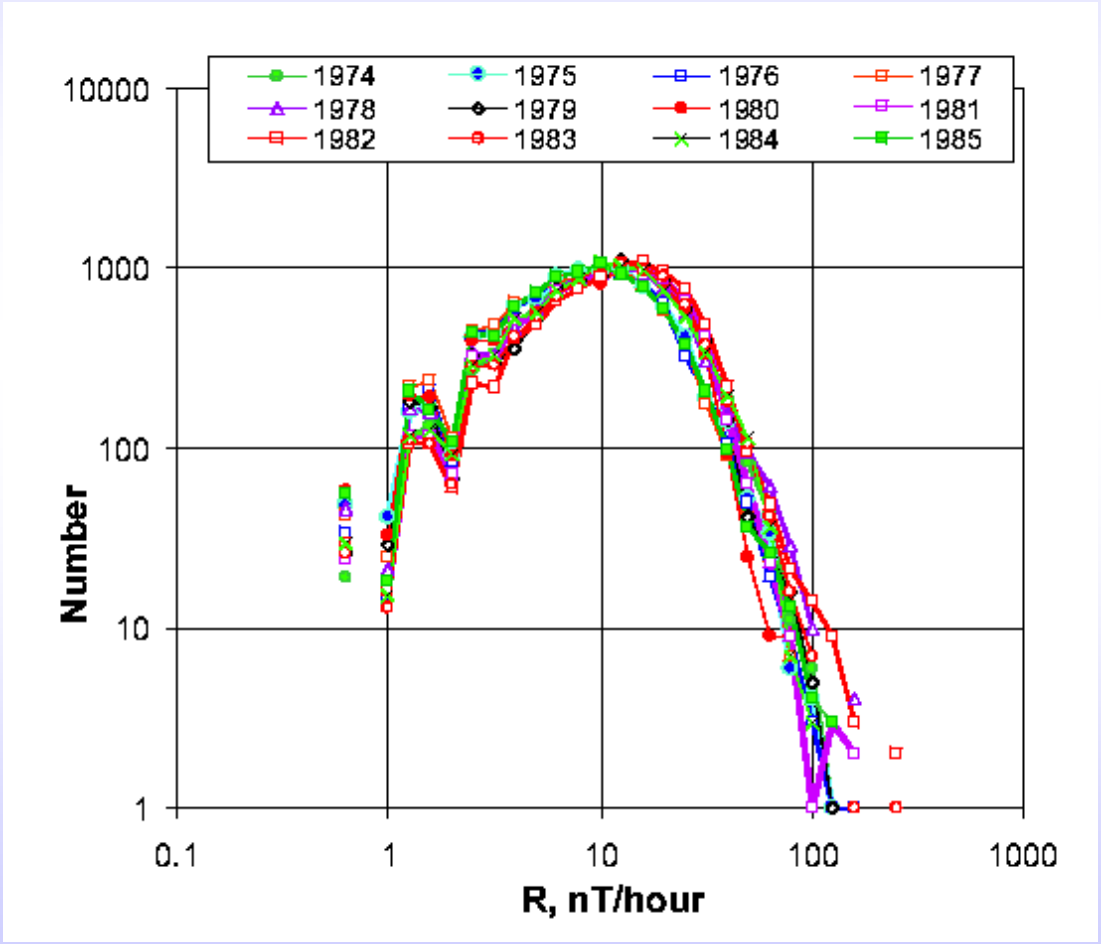
The analysis resulted firm statistical conclusions:

The observed variability of geomagnetic vector and specific distribution of its rate and variation suggests cascading nature of the underlining process characterized by power-law scaling, i.e., Self-Organized Criticality.

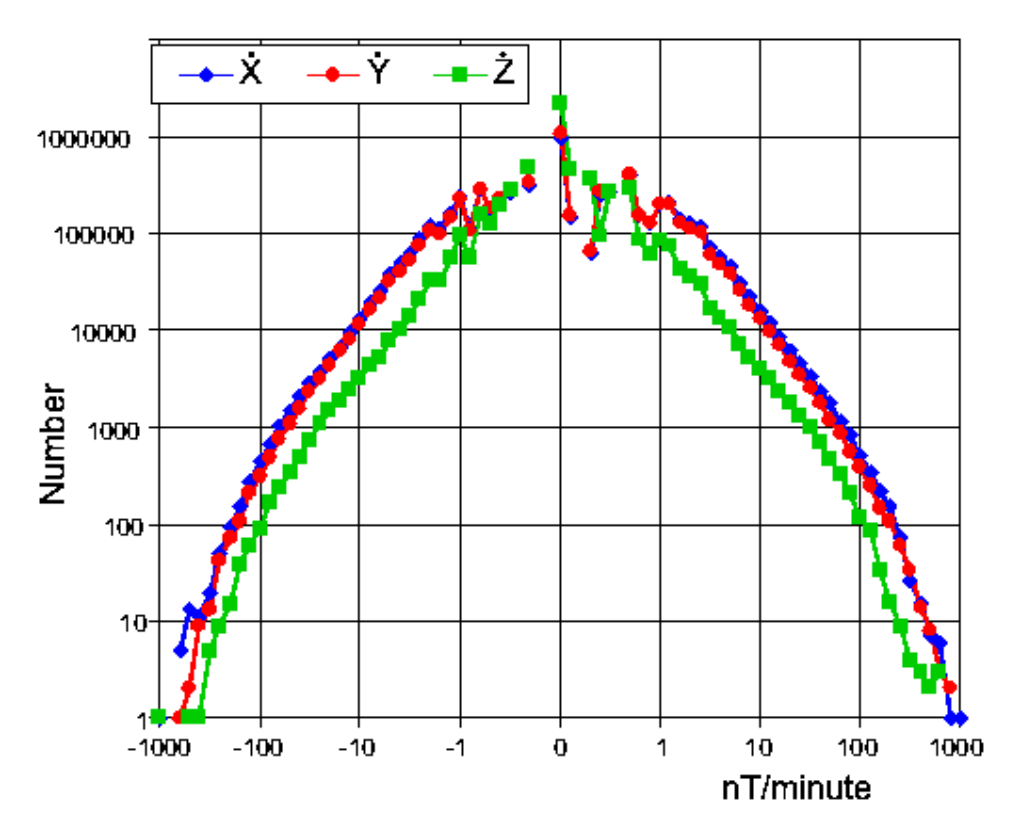
Histograms computed from daily means at Eskdalemuir.



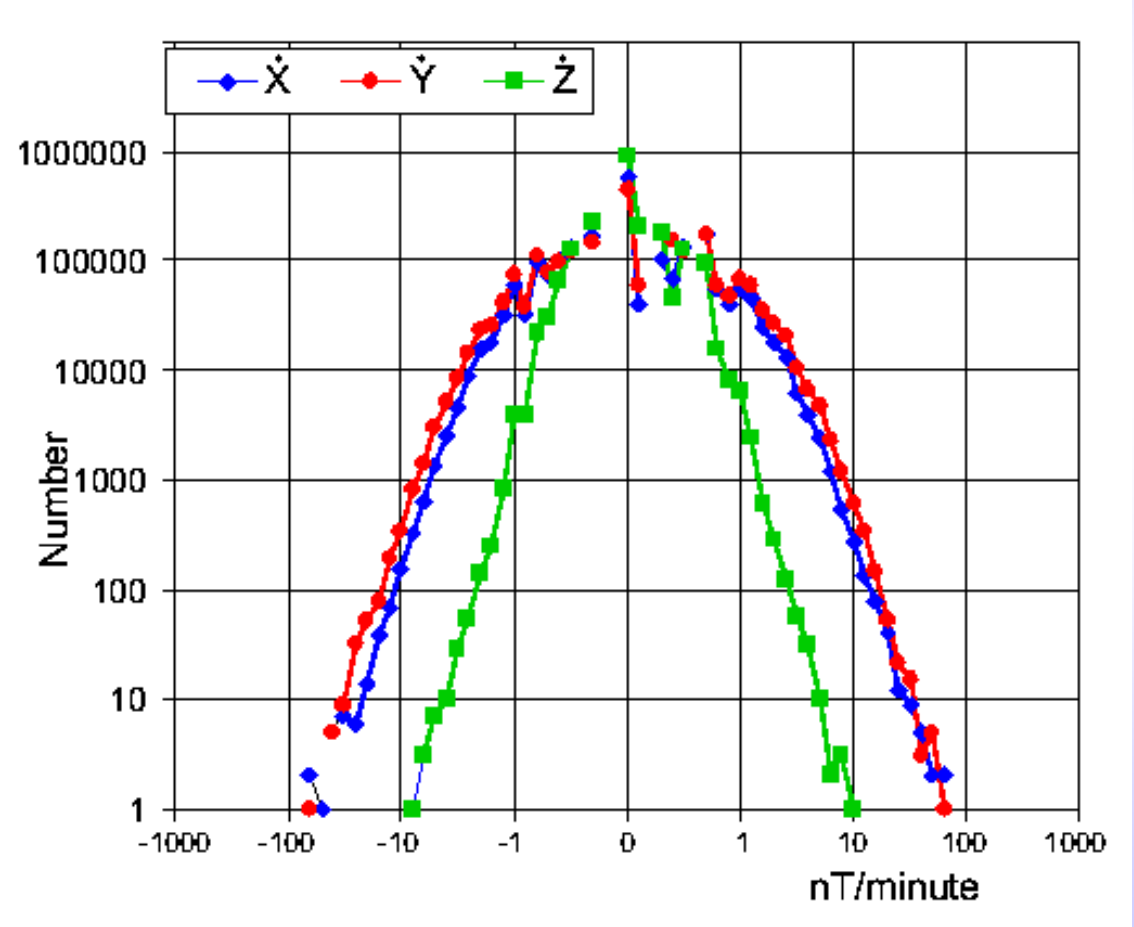
Annual histograms computed from hourly means at Chambon-la-Forêt



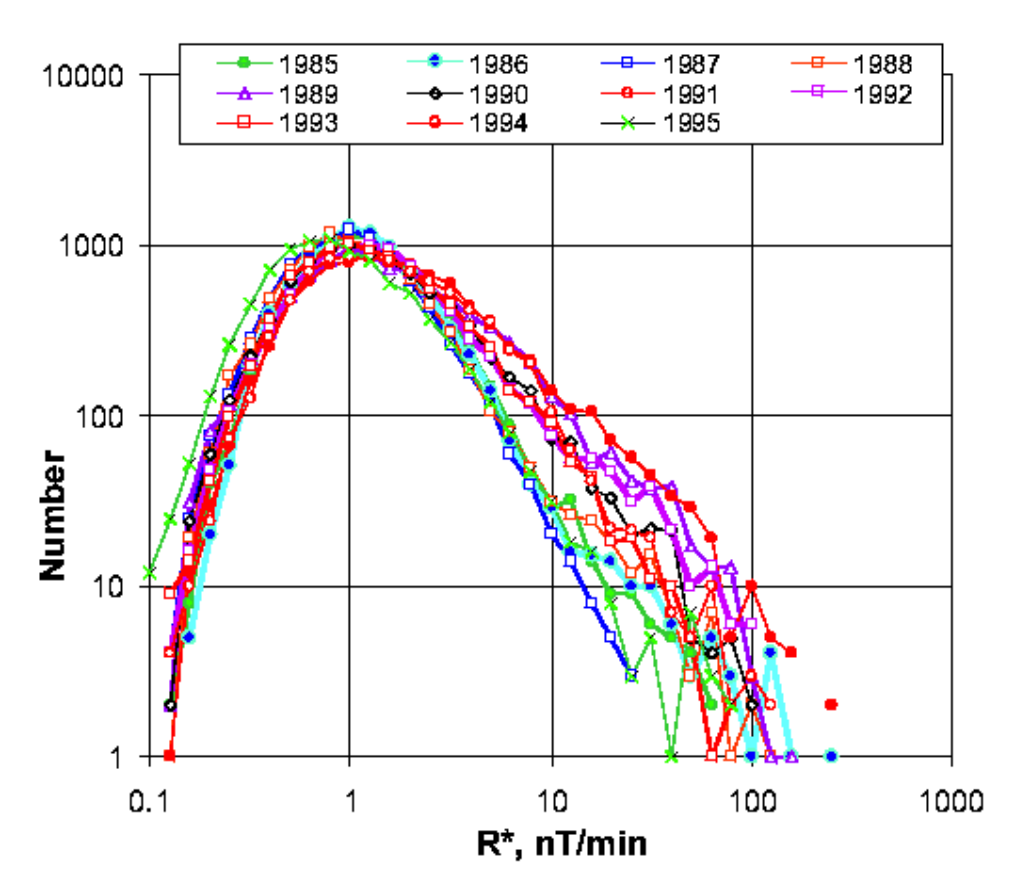
Histograms computed from minute means at Port-aux-Français



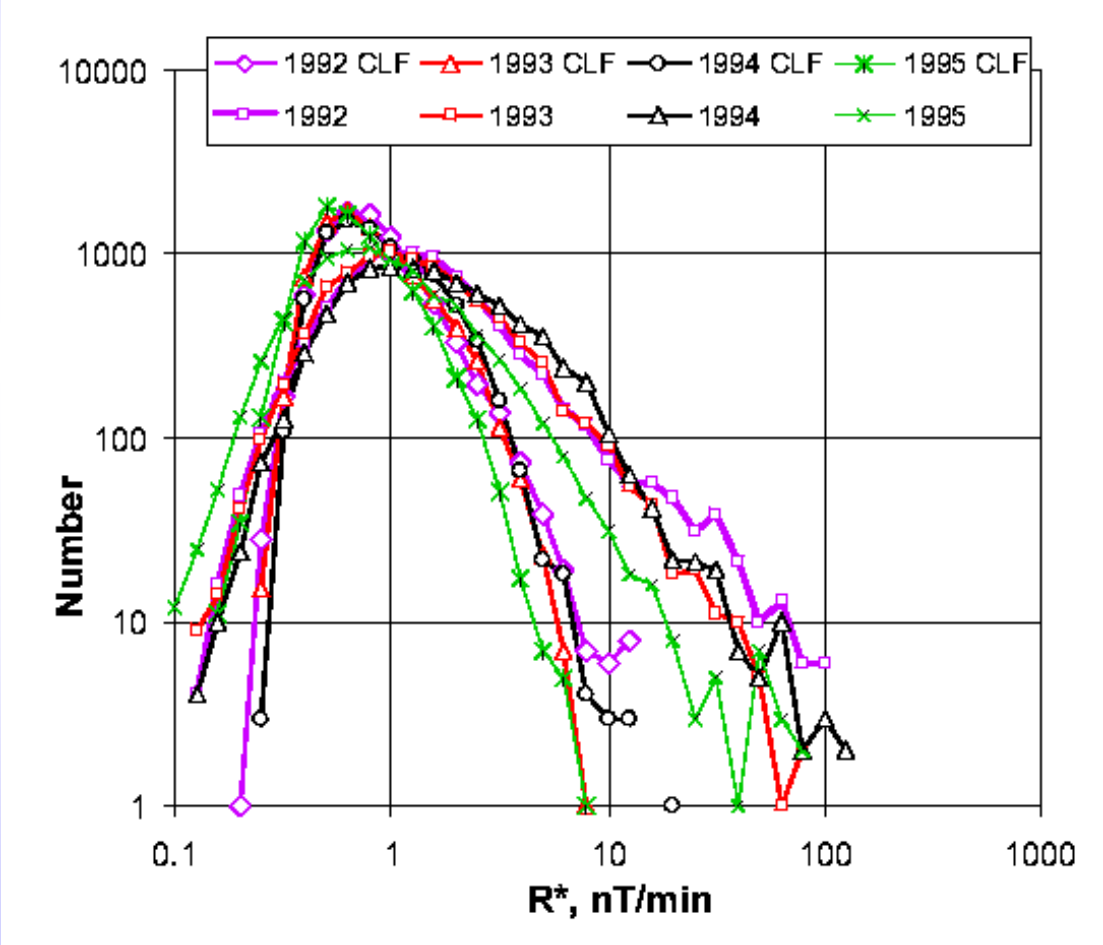
Histograms computed from minute means at Chambon-la-Forêt



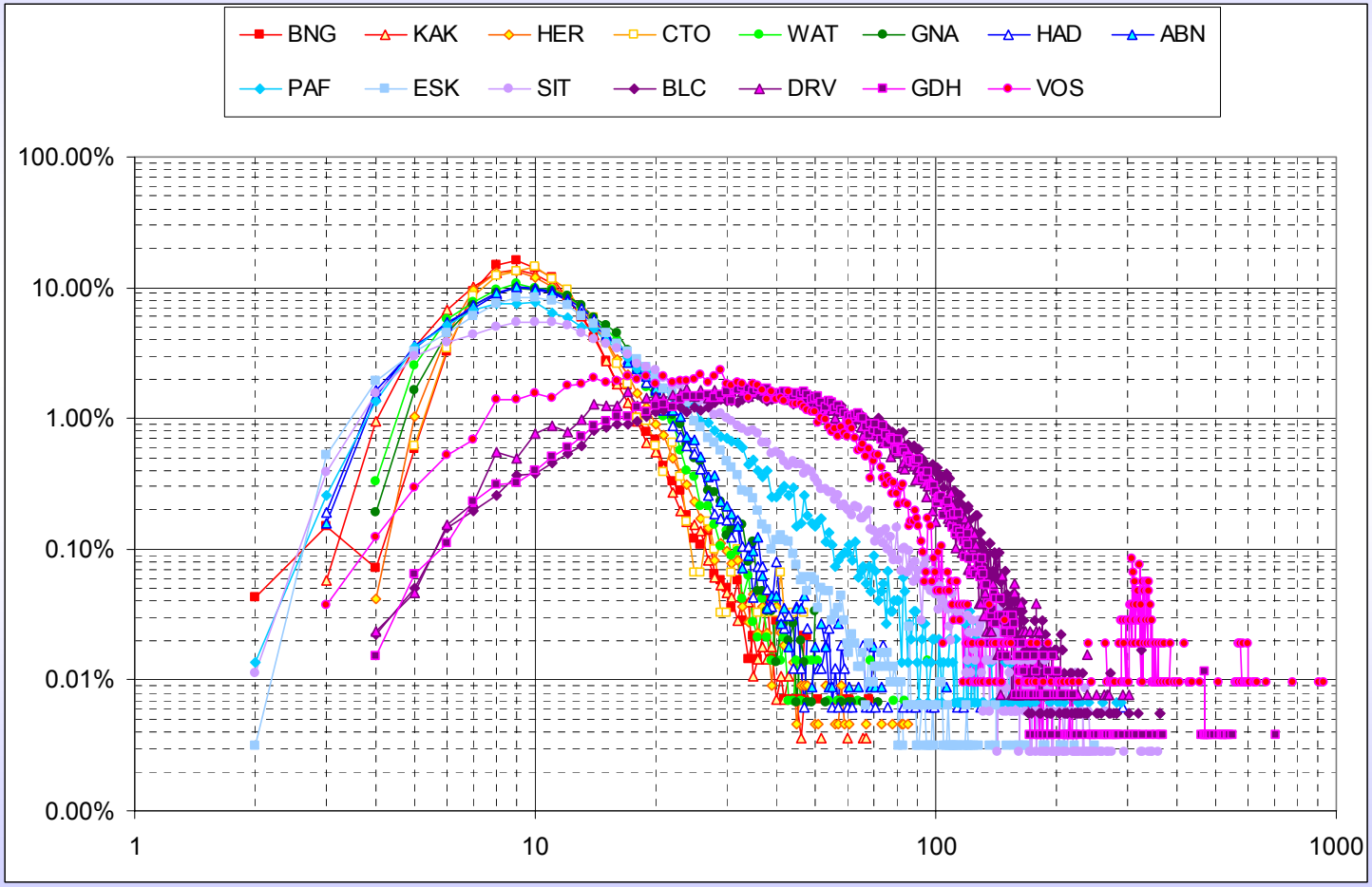
Histograms of R computed from minute means at Port-aux-Français



Comparison of the annual histograms computed from minute means at CLF and PAF.



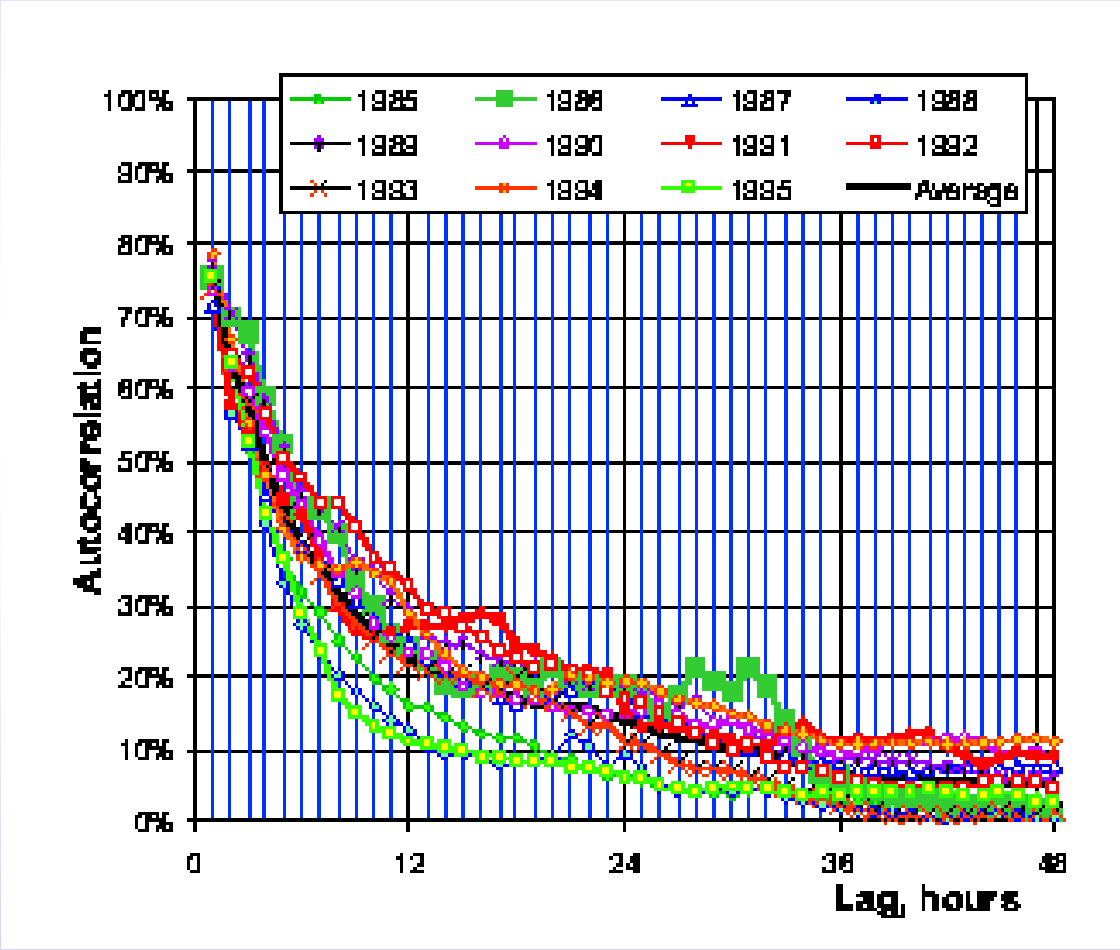
Comparison of the annual PDFs of the magnetic differential R computed from minute means.



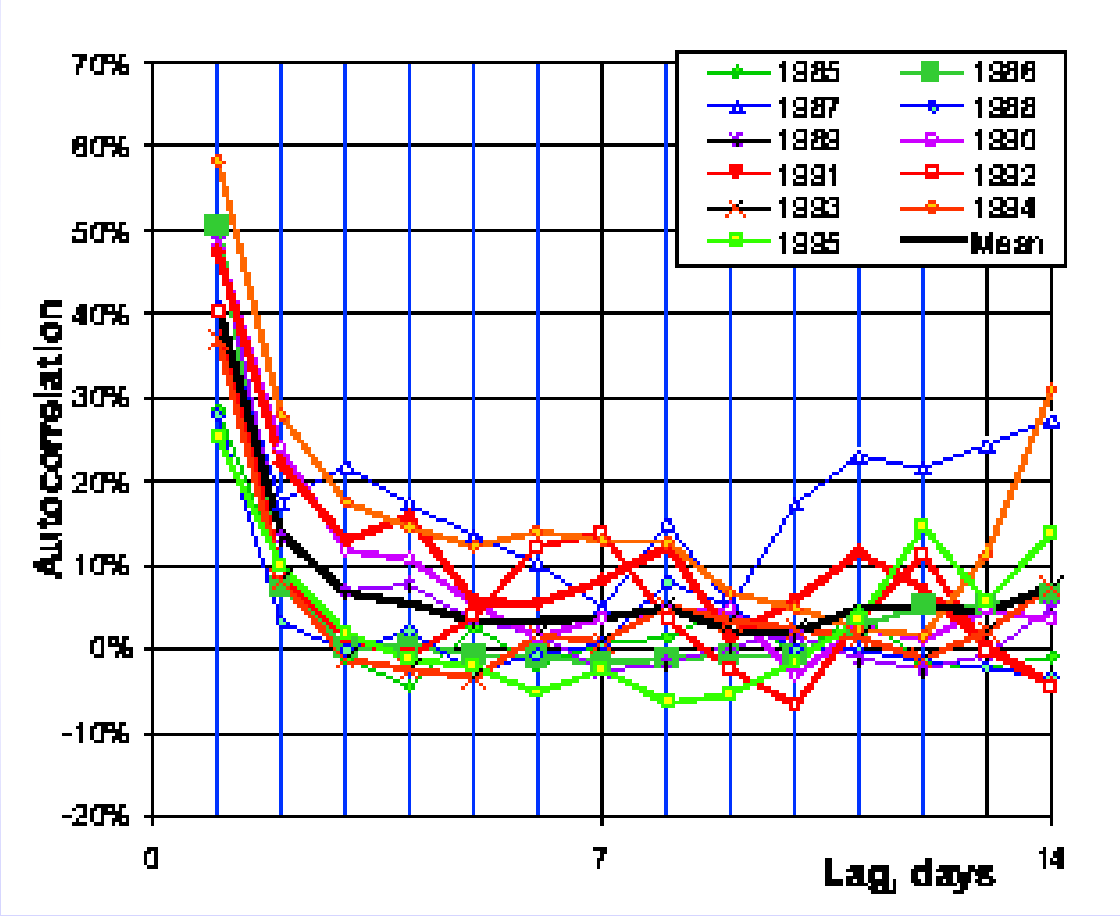
The magnetic vector differential distribution for each of the three components and its norm shows a systematic power-law increase of the density from the smallest values to the bulk distribution and power-law decay to the extreme events.

The series of magnetic differential has a high level of autocorrelation from about 40-50% for daily sampling to 60-75% for hourly averages of minute sampling. The autocorrelation depends on location and solar activity, i.e. phase of solar cycle.

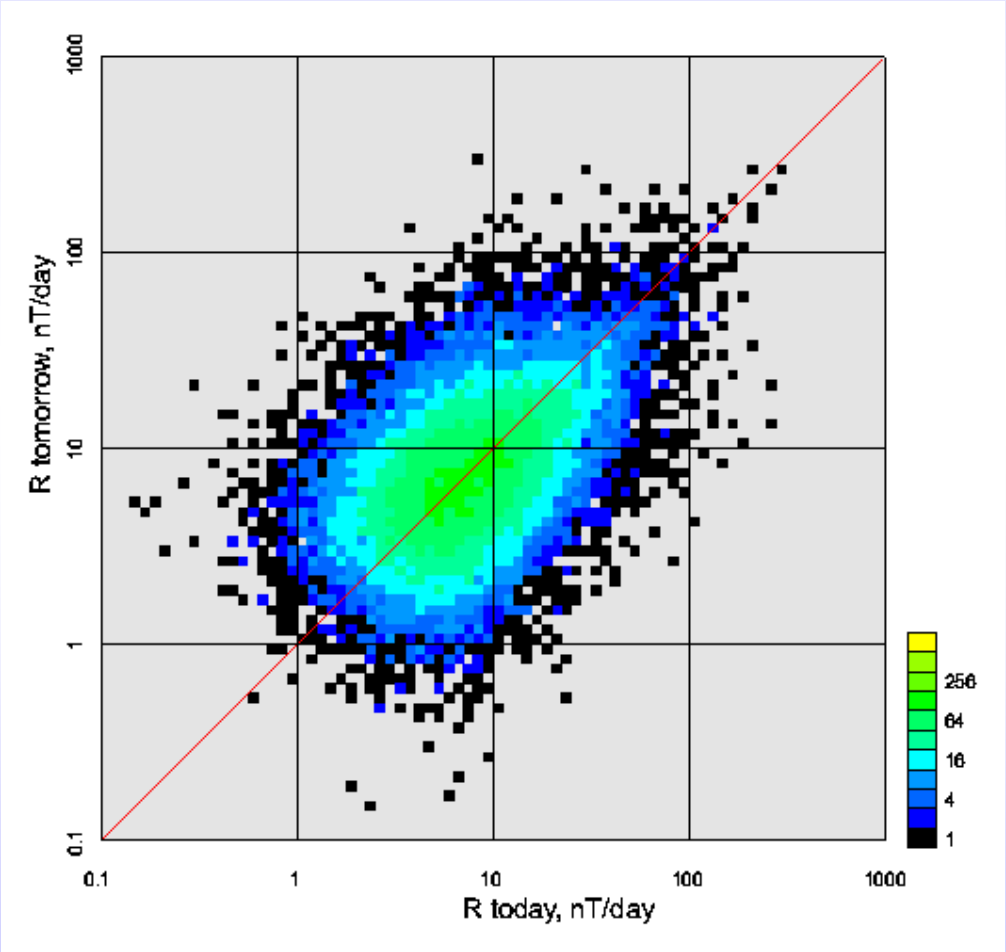
Hourly autocorrelation function of R (*computed from minute means*) at PAF.



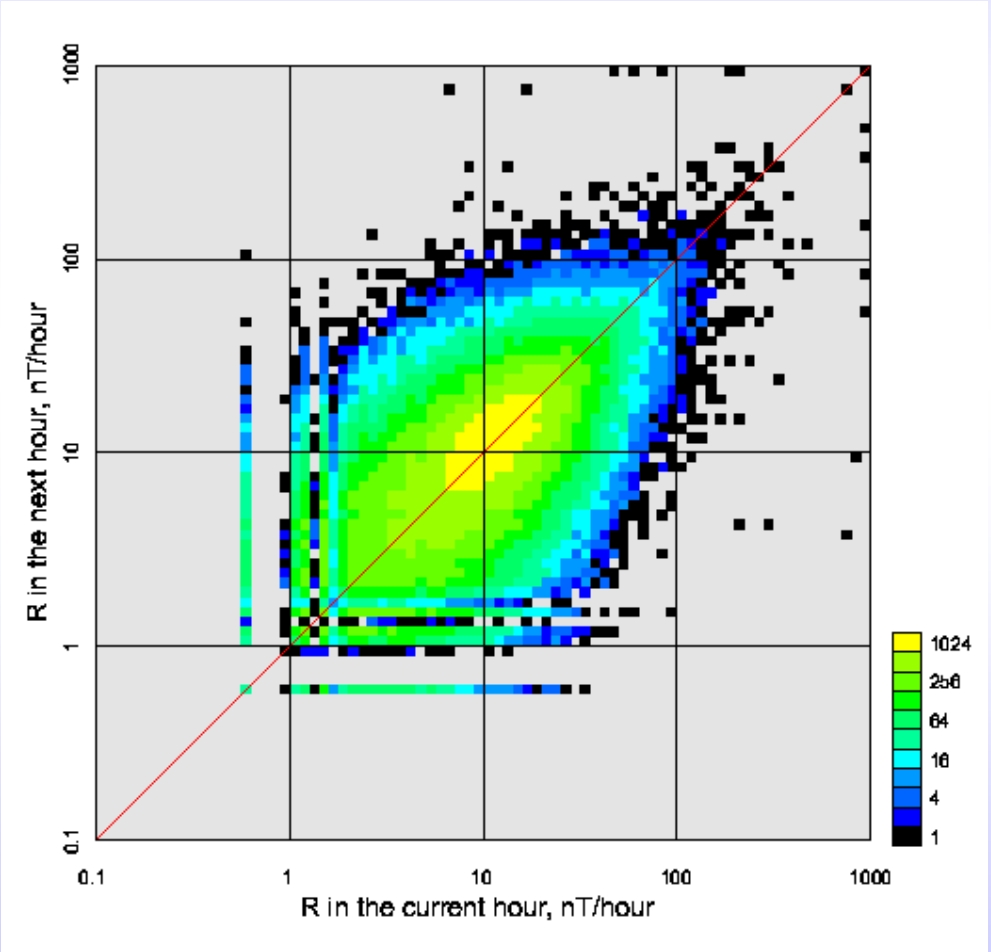
Daily autocorrelation function of R (*computed from minute means*) at PAF.



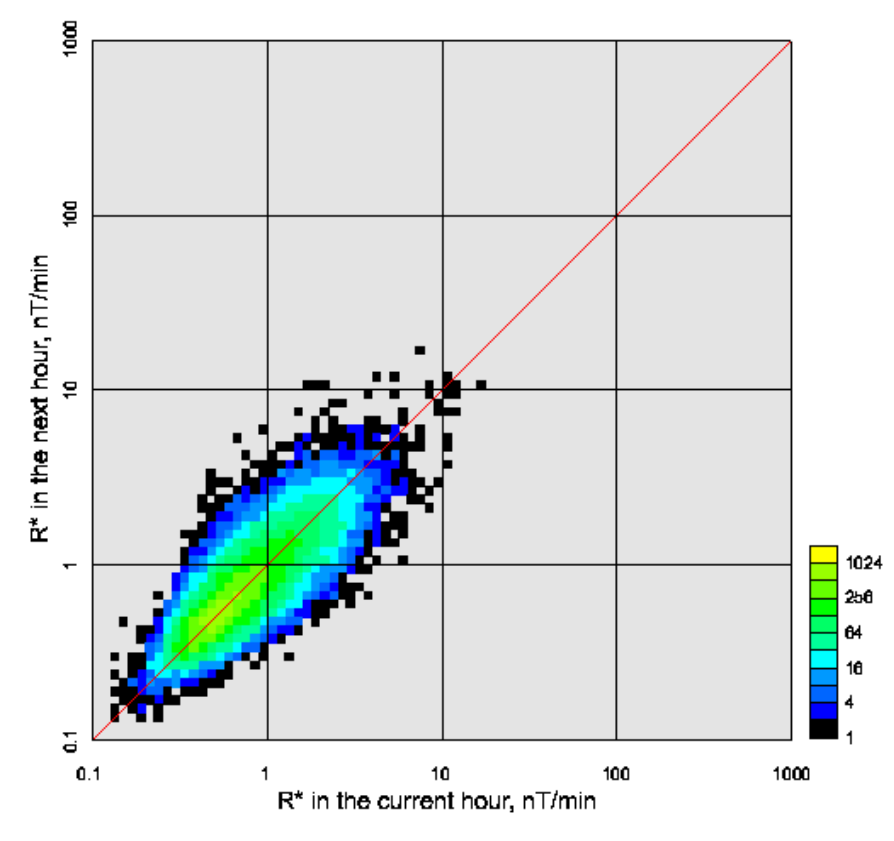
2D histogram computed from daily means at Eskdalemuir.

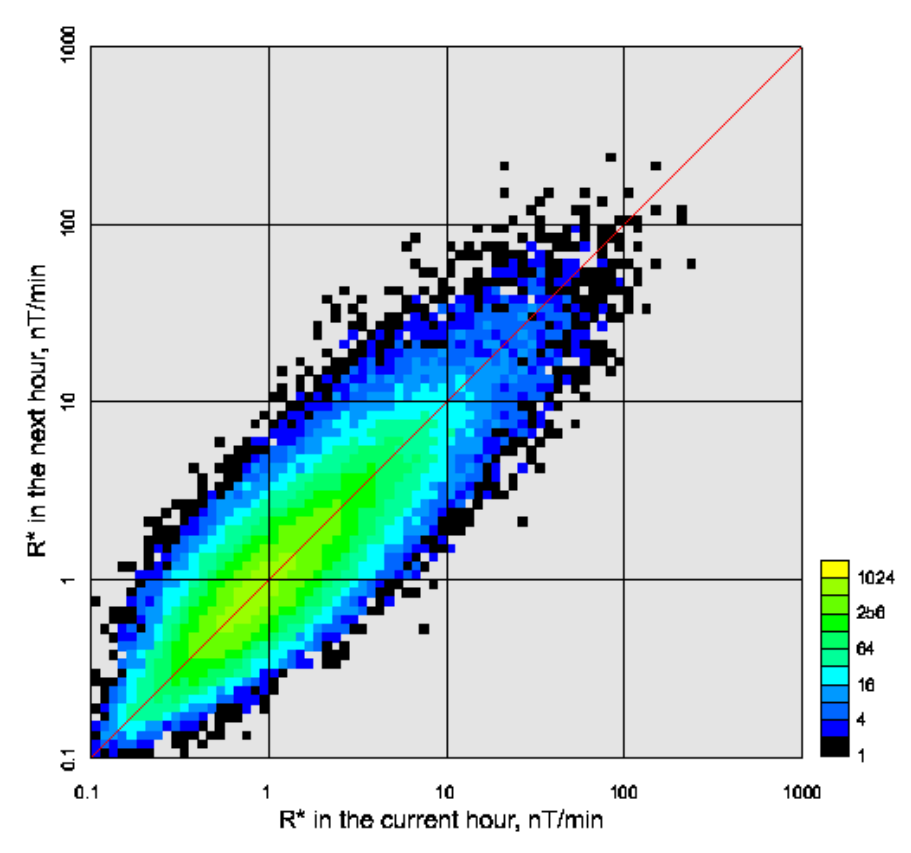


2D histogram computed from hourly means at Chambon-la-Forêt.



2D histograms computed from minute means at Chambon-la-Forêt and Port-aux-Français.





The magnetic differential can be used in a simple prediction scheme:

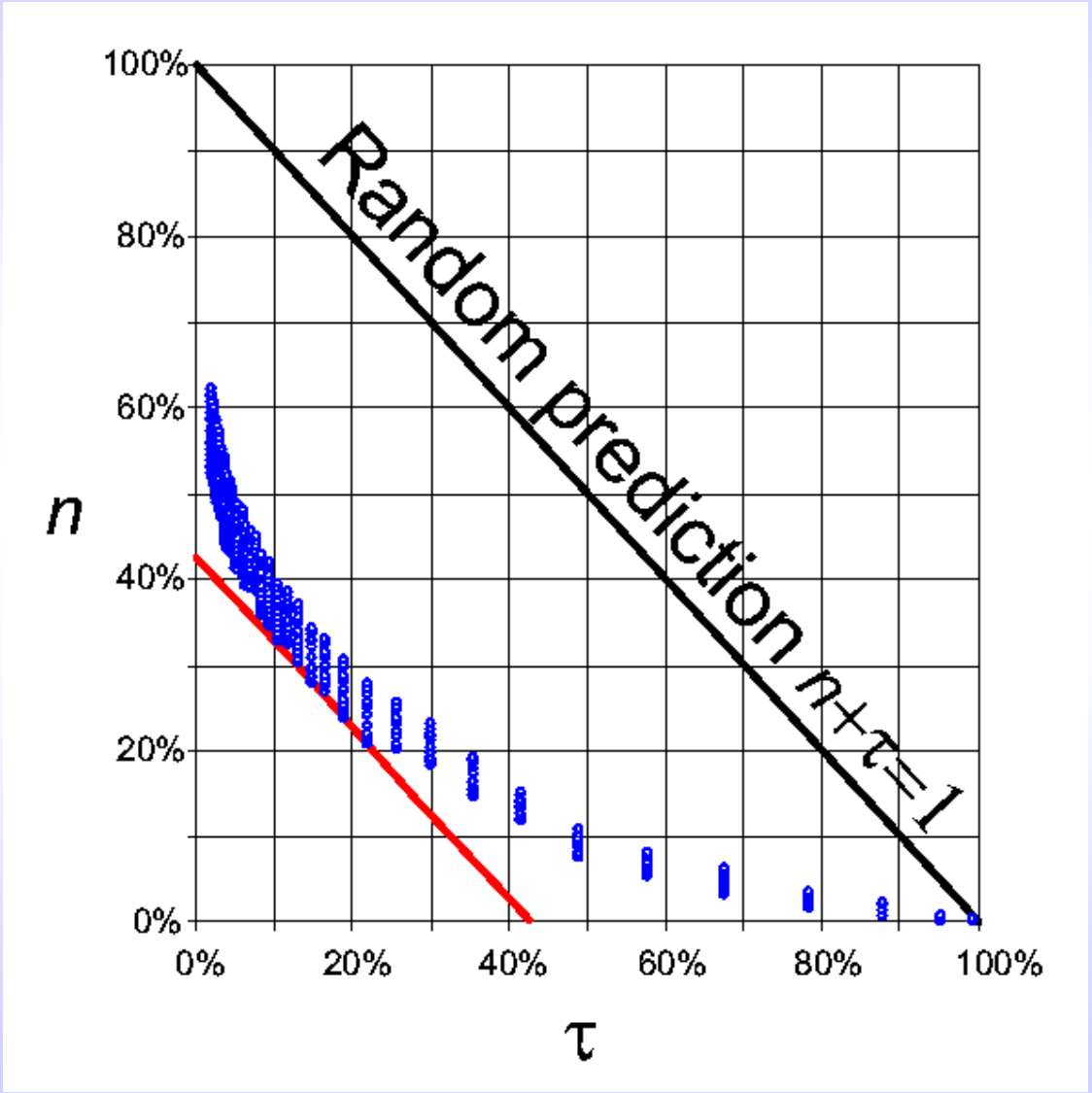
Suppose we are interested in predicting today the extreme events,defined by values of $R > R_0$, for tomorrow.

The simplest prediction scheme suggests to issue an alert for tomorrow if $R > r_0$ today; r_0 and R_0 are parameters.

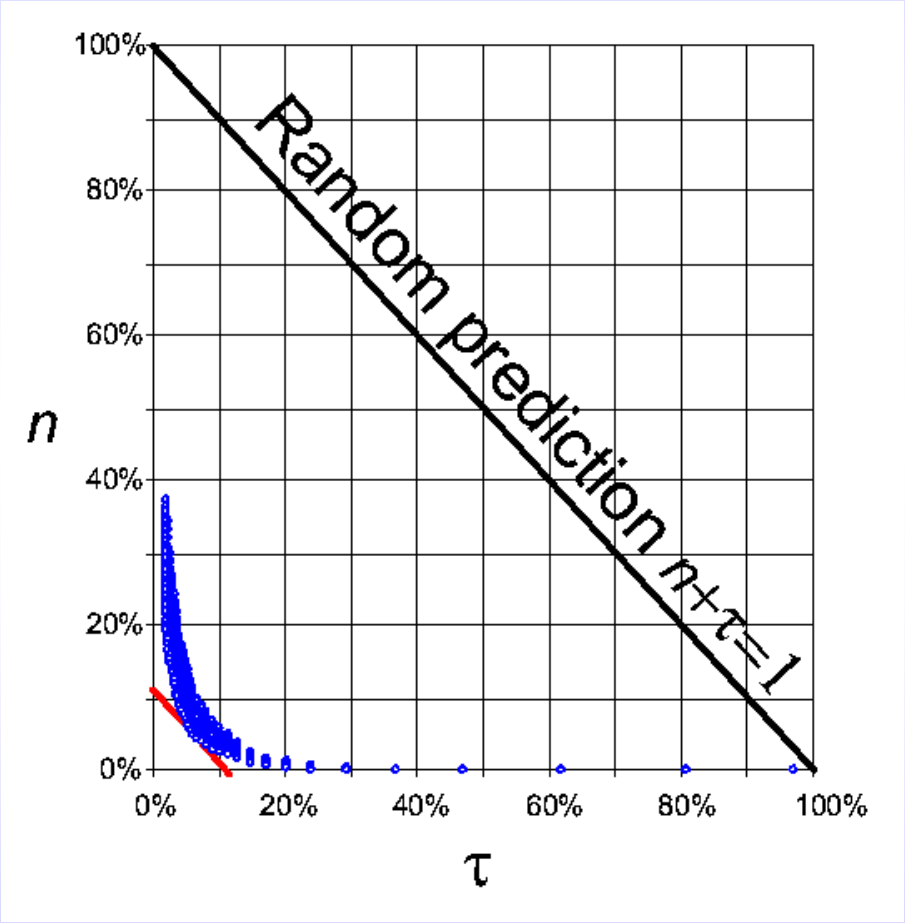
We call the occurrence of a value of R larger than R_0 an extreme event.
We count a success, if it happens
on the alert day, and a failure-to-predict otherwise.

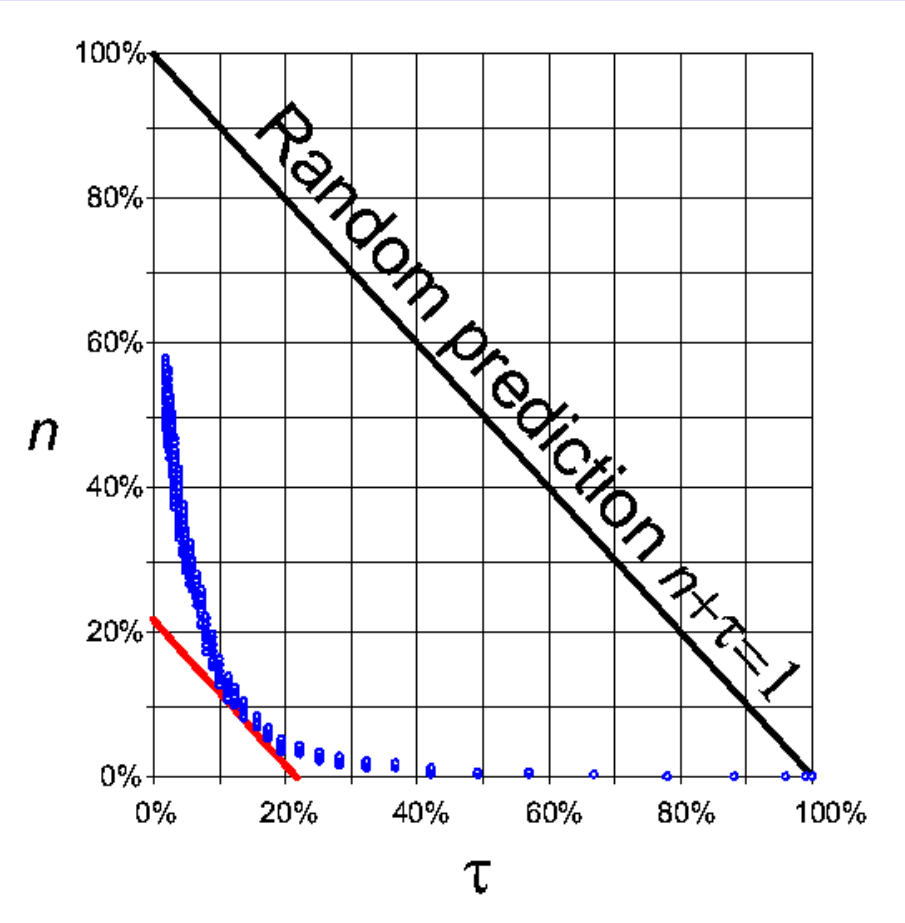
The prediction results, both for the daily and hourly data, are by far a random guessing. The scheme allowed us to quantify in different manner the predictability of the series of variables. It focuses on what can be said about the next value of the variable knowing its current value, e.g., what can be said for tomorrow knowing the situation for today.

Prediction for tomorrow at ESK

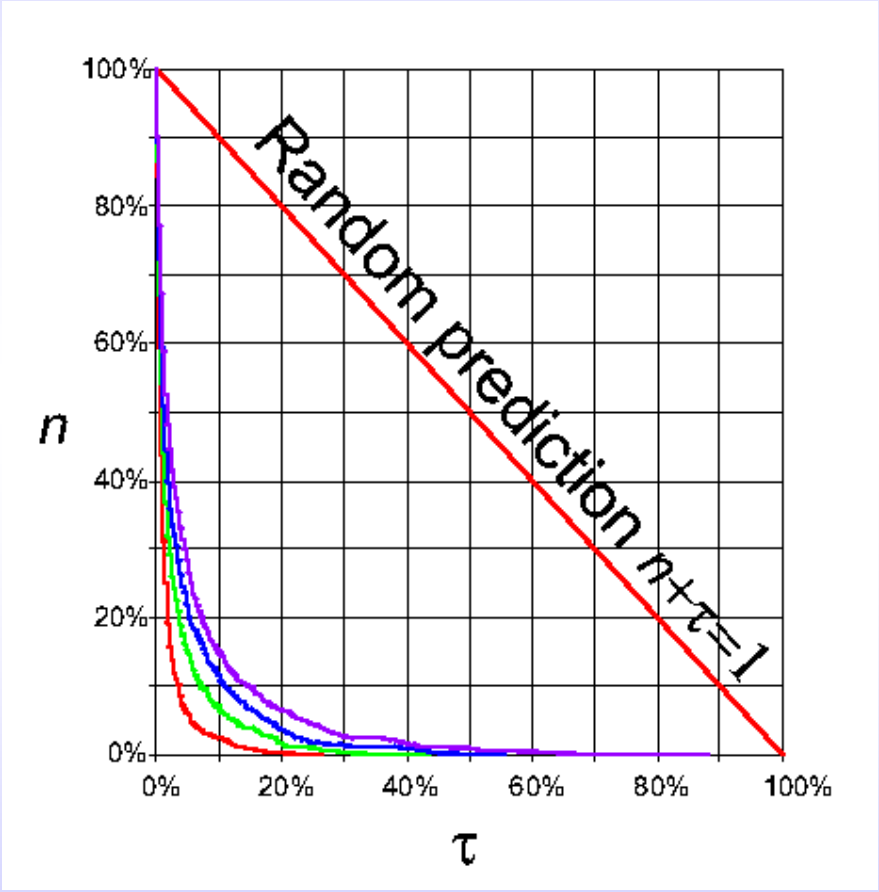


Prediction for the next hour at PAF and CLF



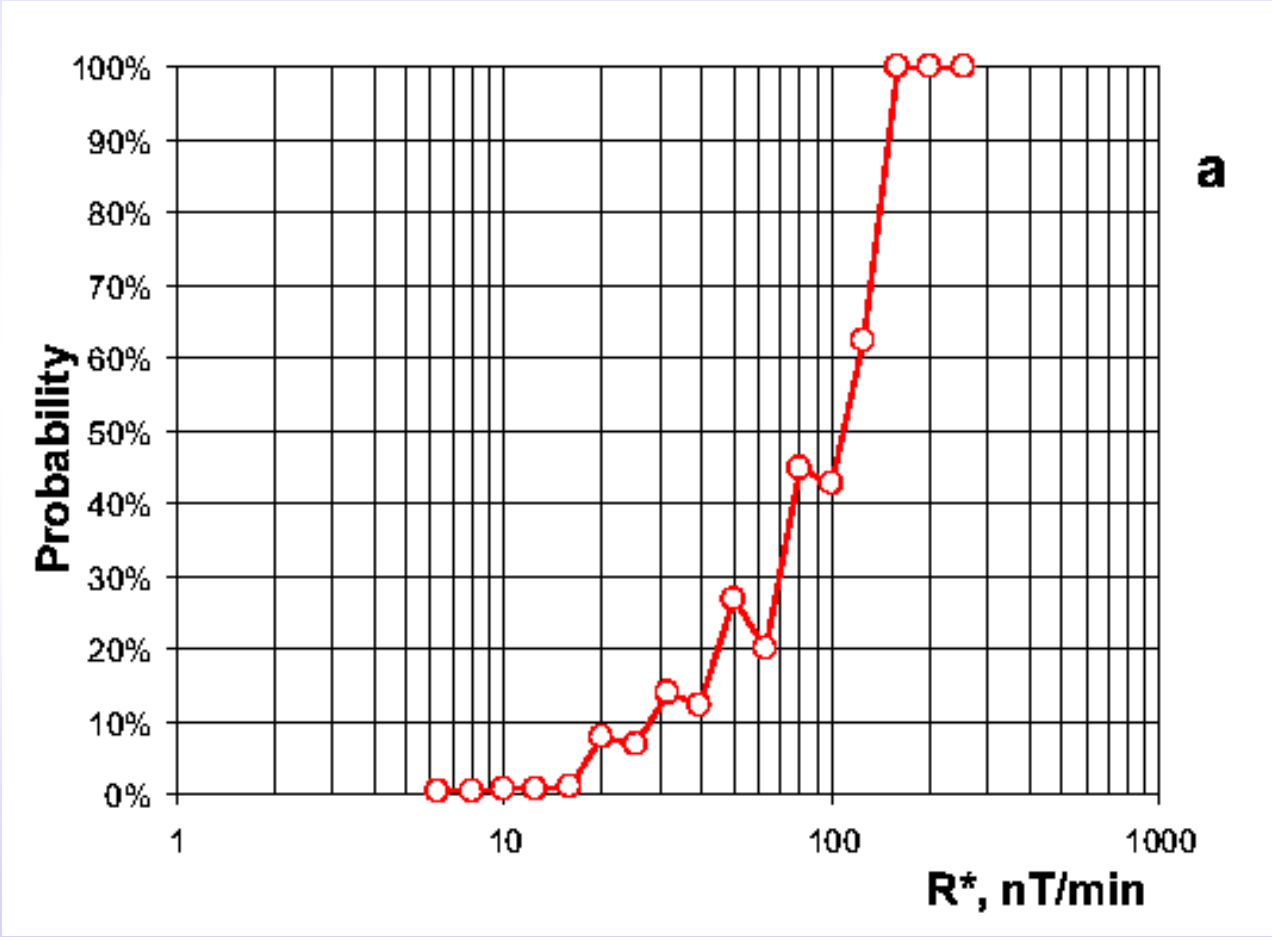


Prediction for the next few hours at PAF

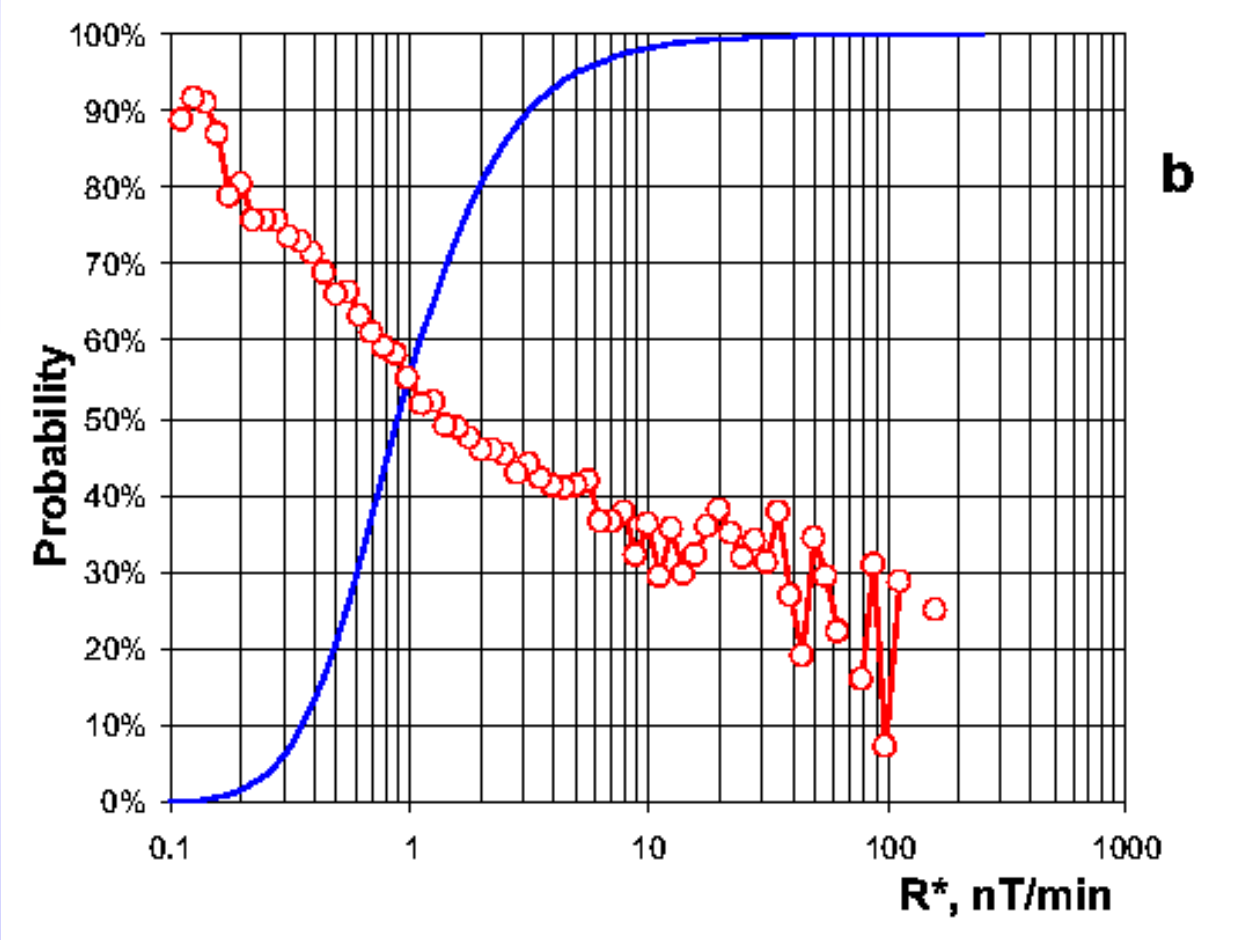


In a similar way, the 2-D empirical distribution of consecutive values of the magnetic differential norm permits computation of conditional probabilities of different type, which might be more appropriate in a specific risk assessment.

The empirical conditional probability of extreme R > 50 nT/min in the next hour at Port-aux-Français



The empirical conditional probability of larger R in the next hour at Port-aux-Français (red).



Our prediction results, although limited, are established in a rigorous way, thus, allowing rigorous testing and adjustments for a specific risk assessment in a real-time experiment.

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