Solar Energetic Particle Event Prediction using advanced signal processing: Challenges and Possibilities

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The occurrence of a Solar Energetic Particle Event (SEPE) is an important phenomenon within Space Weather. The high energy protons and heavy ions can cause major disruptions to the operation of spacecraft in earth orbit and outside the earth's magnetosphere and must be considered for EVA and other manned activities. They may also have an effect on radiation doses received by the crew flying in high altitude aircraft over the polar regions. Currently our understanding of the causes of these events is poor. But what are the prospects for prediction, for example can artificial intelligence techniques be used in the absence of a better understanding of the physics involved?

It is normally assumed that SEPEs are random and statistical models usually assume that they are governed by a Poisson distribution. Little has been done to try to predict their occurrence with lead times of 24 hrs or more and the key question that arises is whether the assumption of randomness is correct or is there some memory, perhaps even long term, due to their association with active regions. The possibilities of using such techniques as neural networks and wavelet techniques are explored. The results of neural network modelling based on x-ray flux ratios as inputs are presented along with some preliminary results from the use of discrete wavelets combined with neural networks; from the latter it would appear that some improvements in the prediction success (i.e. whether an event will occur or not) can be obtained by using wavelet coefficients as inputs to the neural network but at the expense of a higher false alarm rate. Two other possible future research avenues that may help in the development of useful forecasting tools are briefly discussed. These are the modelling of the time behaviour based on an analogy with the equations of motion of fluids using a shell model for turbulence and waiting time statistics and the diffusion of entropy. Ultimately, the problem awaits more observational data from big events and a more detailed understanding of the conditions on the sun prior to event initiation.