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Developing an alarm system for space weather hazards using the variation of chaotic characteristics of solar activity indices

M. Mirmomeni (1), C. Lucas (1, 2), B. N. Araabi (1, 2)

(1) Control and Intelligent Processing Center of Excellence, College of Engineering, School of Electrical and Computer Eng. Department of University of Tehran, Tehran, Iran, (2) School of Cognitive Sciences, Institute for studies in theoretical Physics and Mathematics, Tehran, Iran

(mirmomeni@ut.ac.ir /Fax: +98 21-88725029 / Phone: +98 21-88020403, lucas@ipm.ir, lucas@ut.ac.ir / Fax: +98 21-88725029 / Phone: +98 21-88020403, araabi@ut.ac.ir / Fax: +98 21-88725029 / Phone: +98 21-88020403)

The dimensions of space challenge the human powers of imagination. The numbers are difficult to grasp: 150 million kilometers as the distance between earth and sun! Although far away, the sun and the other stars are the source of effects which have a considerably stronger influence upon our lives than has been assumed until recently. Among these phenomena, space weather hazards as a term which generally refers to the dynamic, highly variable conditions in the geospace environment in recent years become a major area of investigation, especially due to the advent of satellite technology. Design of reliable alerting and warning systems is of utmost importance and international collaboration is needed to develop accurate prediction methodologies before the next strikes. It is shown that the cyclic solar activity has chaotic characteristics especially during storm time. One of the most important tools for eliciting the chaotic trends is the minimum embedding dimension and “Lyapunov Exponents” which is a useful measure of the stability of a dynamic system. It is shown that the EDs and LEs of solar activity indices begin to vary in such a way that an obvious pattern can be detected about 10 steps sooner before storm begins. In addition, there is a drop off in the largest Lyapunov exponent during magnetic storms and CMEs. In this paper, the variation of Embedding Dimension (ED) and Lyapunov Exponents (LE) for some so-

lar activity indices is used to design an alarm system for space weather hazards. Two well-known hazards are considered to evaluate the performance of the proposed alarm system in this paper. The first storm is the major magnetic storm on 13 March 1989, which shuts down the power supply system in Québec, Canada and the second one is a Coronal Mass Ejection (CME) on 11 January 1997 which causes the most widely known disturbances and failures for satellites: the failure of Telstar 401 satellite. Simulation results depict the power of the proposed method in long-term prediction of such hazards.