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Using Statistical Process Control for detecting anomalies in multivariate spatiotemporal Earth Observations

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The number of available Earth observations (EOs) is currently substantially increasing. Detecting anomalous patterns in these multivariate time series is an important step in identifying changes in the underlying dynamical system. Likewise, data quality issues might result in anomalous multivariate data constellations and have to be identified before corrupting subsequent analyses. In industrial application a common strategy is to monitor production chains with several sensors coupled to some statistical process control (SPC) algorithm. The basic idea is to raise an alarm when these sensor data depict some anomalous pattern according to the SPC, i.e. the production chain is considered 'out of control'. In fact, the industrial applications are conceptually similar to the on-line monitoring of EOs. However, algorithms used in the context of SPC or process monitoring are rarely considered for supervising multivariate spatio-temporal Earth observations. The objective of this study is to exploit the potential and transferability of SPC concepts to Earth system applications. We compare a range of different algorithms typically applied by SPC systems and evaluate their capability to detect e.g. known extreme events in land surface processes. Specifically two main issues are addressed: (1) identifying the most suitable combination of data pre-processing and detection algorithm for a specific type of event and (2) analyzing the limits of the individual approaches with respect to the magnitude, spatio-temporal size of the event as well as the data's signal to noise ratio. Extensive artificial data sets that represent the typical properties of Earth observations are used in this study. Our results show that the majority of the algorithms used can be considered for the detection of multivariate spatiotemporal events and directly transferred to real Earth observation data as currently assembled in different projects at the European scale, e.g. http://baci-h2020.eu/index.php/ and http://earthsystemdatacube.net/. Known anomalies such as the Russian heatwave are detected as well as anomalies which are not detectable with univariate methods.