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Title: New empirical methods for correction of meteorological effects on cosmic ray muons
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Executive Summary

Motivation

Changing conditions in the atmosphere affect the propagation of muon component of secondary cosmic rays (CR). These meteorological effects (primarily barometric and temperature effect) need to be corrected for in order to increase the sensitivity of ground based muon detectors to the variations of primary cosmic rays.

Even though several well established methods for correction of meteorological effects on cosmic ray muons exist, they are all at least in some part approximative. The idea behind this work is to introduce a new empirical method that will assume as little as possible a priori, will take maximum information about meteorological parameters into account, will be relatively easy to use and applicable to any muon detector, would not depend on the topology of the surrounding terrain or infrastructure of the laboratory, and can be easily generalized to take into account larger set of meteorological variables than is commonly used. Ideally it would also provide some new insights beyond current theoretical description of this topic.

Methods

Two new methods, somewhat similar in nature, are introduced: PCA method (based on principal component analysis) and MVA method (based on multivariate analysis employing machine learning techniques).

Principal component analysis (PCA) is a technique widely used for decorrelation and dimensionality reduction of highly correlated sets of variables. Here, we have used it to transform the initial set of correlated meteorological variables into a new set of uncorrelated principal components. Set was then reduced from 26 variables to five significant ones, which were then used in analysis that yielded corrected muon count rates.

Multivariate analysis (MVA) utilizing machine learning techniques is successfully used for modeling of highly correlated systems. Here, we have trained different machine learning algorithms to predict the muon count rates using meteorological variables as input. Assuming all variation is due to variation of input variables, predicted output can be used for correction of muon count rates. Based on several tests, best performing algorithms have been selected.

Results

We have analyzed the effects of newly introduced corrections on periodic and aperiodic variations of cosmic rays and have compared the results with the reference correction method and neutron monitor data.

New methods seem to be as, if not more, effective than most widely used correction techniques, and possibly indicate there is some part of meteorological effects currently not taken into account by theory.