Reconstruction of vegetation index and Phenology lab enhanced vegetation index record: An application of weak solution to stochastic partial differential equations approach

A long-term record of the Earth's vegetation index record is important in studies of global climate change and feedbacks. Over the last three decades, many satellite based sensor platforms have generated multiple vegetation records. The Advanced Very High Resolution Radiometer (AVHRR) has provided spectral and radiometric measures of the Earth since 1978. The Global Inventory Modelling and Mapping Studies (GIMMS) have utilized the AVHRR products to develop long-term vegetation index records from visible red and near infrared lights. Physical and statistical models have been used to further improve the inconsistencies and reliability of the record. However, bias and inconsistencies persist hindering accurate assessment of biophysical and physiological processes. The problem is compounded by the inaccurate estimation of such processes by the Normalized Difference Vegetation Index (NDVI) particularly in dense vegetation areas. Moderate Resolution Imaging Spector radiometer (MODIS) do provide an alternative to NDVI, Enhanced Vegetation Index (EVI) records, but only available from the year 2000 which is not long enough for any meaningful climate change analysis. Vegetation Index & Phenology Lab (VIP) has developed a new EVI record, back predicted to 1981 at 5km spatial resolution 15day time steps globally. However, this record has got large persistent gaps necessitating further processing. In this Thesis we aim: To establish whether there exist a link between Gaussian Random Field (GRF) and Gaussian Markov Random field, the weak solution to SPDE approach; to reconstruct the new long-term (30+ years) EVI record using continuous time series model based on Stochastic Partial Differential Equations (SPDE) approach; and to develop a spatiotemporal dynamic linear model for further gap-filling and smoothing the records. The posterior marginal distributions were approximated with Integrated Nested Laplace Approximation (INLA). The continuous time series components (trend, season, and cyclic) were expressed with special SPDE functionalities. Where dynamic parameters were involved, relevant harmonic sine and cosine terms were used as weights to the spatiotemporal dynamic terms. Random effects were adjusted for in the framework of hierarchical models. The marginal xiii posterior distributions for both parameters and hyper-parameters were obtained using numerical approximation technique based on the INLA method. The ability of the individual approximate Bayesian models based on the SPDE approach to accurately predict *in situ* leaf area index (LAI) data were compared to corresponding models that have been widely used among the research community. Our approach enables continuity of the new record (VIP) by filling-in gaps and improving consistency by smoothing. Many studies exist where new gap-filling and smoothing methods are tested but this study differentiates itself by the fact that it compares results with *in situ* data. The newly reconstructed record proved to be more reliable by accurately estimating the *in situ* LAI product.