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A Spatiotemporal data Fusion method for generating a high-resolution, regular and cloud-free time series of satellite images

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Scientific research of land surface dynamics in heterogeneous landscapes often require remote sensing data with high resolutions in both space and time. However, single sensor could not provide such data at both high resolutions. In addition, because of cloud pollution, images are often incomplete. Spatiotemporal data fusion methods is a feasible solution for the aforementioned data problem. However, for existing data fusion methods, it is difficult to address the problem constructed regular and cloud-free dense time-series images with high spatial resolution. To address these limitations of current spatiotemporal data fusion methods, in this paper, we presented a novel data fusion method for fusing multi-source satellite data to generate s a high-resolution, regular and cloud-free time series of satellite images.

We incorporates geostatistical theory into the fusion method, and takes the pixel value as a random variable which is composed of trend and a zero-mean second-order stationary residual. To fuse satellite images, we use the coarse-resolution image with high frequency observation to capture the trend in time, and use Kriging interpolation to obtain the residual in fine-resolution scale to provide the informative spatial information. In this paper, in order to avoid the smoothing effect caused by spatial interpolation, Kriging interpolation is performed only in time dimension. For certain region, the temporal correlation between pixels is fixed after the data reach stationary. So for getting the weight in temporal Kriging interpolation, we can use the residuals obtained from coarse-resolution images to construct the temporal covariance model. The predicted fine-resolution image can be obtained by returning the trend value of pixel to their own residual until the each pixel value was obtained. The advantage of the algorithm is to accurately predict fine-resolution images in heterogeneous areas by integrating all available information in the time-series images with fine spatial resolution.

We tested our method to fuse NDVI of MODIS and Landsat at Bahia State where has heterogeneous landscape, and generated 8-day time series of NDVI for the whole year of 2016 at 30m resolution. By cross-validation, the average R^2 and RMSE between NDVI from fused images and from observed images can reach 95% and 0.0411, respectively. In addition, experiments demonstrated that our method also can capture correct texture patterns. These promising results demonstrated this novel method can provide effective means to construct regular and cloud-free

time series with high spatiotemporal resolution. Theoretically, the method can predict the fine-resolution data required on any given day. Such a capability is helpful for monitoring near-real-time land surface and ecological dynamics at the high-resolution scales most relevant to human activities.