Geophysical Research Abstracts
Vol. 17, EGU2015-6062, 2015
EGU General Assembly 2015

Rendering Future Vegetation Change across Large Regions of the US

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We use two Machine Learning techniques, Decision Trees (DT) and Neural Networks (NN), to provide classified images and photorealistic renderings of future vegetation cover at three large regions in the US. The training data used to generate current vegetation cover include Landsat surface reflectance images, USGS Land Cover maps, 50 years of mean annual temperature and precipitation for the period 1950 - 2000, elevation, aspect and slope data. Present vegetation cover was generated on a 100m grid. Future vegetation cover for the period 2061- 2080 was predicted using the 1 km resolution bias corrected data from the NASA Goddard Institute for Space Studies Global Climate Model E simulation.

The three test regions encompass a wide range of climatic gradients, topographic variation, and vegetation cover. The central Oregon site covers 19,182 square km and includes the Ochoco and Malheur National Forest. Vegetation cover is 50% evergreen forest and 50% shrubs and scrubland. The northwest Washington site covers 14,182 square km. Vegetation cover is 60% evergreen forest, 14% scrubs, 7% grassland, and 7% barren land. The remainder of the area includes deciduous forest, perennial snow cover, and wetlands. The third site, the Jemez mountain region of north central New Mexico, covers 5,500 square km. Vegetation cover is 47% evergreen forest, 31% shrubs, 13% grasses, and 3% deciduous forest. The remainder of the area includes developed and cultivated areas and wetlands.

Using the above mentioned data sets we first trained our DT and NN models to reproduce current vegetation. The land cover classified images were compared directly to the USGS land cover data. The photorealistic generated vegetation images were compared directly to the remotely sensed surface reflectance maps. For all three sites, similarity between generated and observed vegetation cover was quite remarkable.

The three trained models were then used to explore what the equilibrium vegetation would look like for the period 2061 - 2080. The predicted mean annual air temperature change for the three sites ranged from + 1.8°C to + 2.3°C. Precipitation for the three sites changed little. In Oregon, this resulted in a 37% shift of forested areas to shrub vegetation. In New Mexico, shrubs and evergreen vegetation increased by 18% and 5%, respectively. Deciduous and grassland vegetation decreased by 90% and 52%, respectively. In Washington, evergreen vegetation cover decreased by 4.5%. Deciduous vegetation increase by 25%. Shrubs and grasslands increased by 15% and 7%, respectively. Perennial snow cover on mountain tops fell by 46%.

Beyond rendering a view of future vegetation cover, we also extracted information regarding the relative controls that climate and topography exert over local vegetation. The three most dominant controls are elevation (most dominant), temperature, and precipitation. In summary, we demonstrate a framework for rendering potential future vegetation in a visually realistic way. Moreover, these machine learning techniques provide a computationally fast framework for exploring the effects of climate change over large-areas and at high-spatial resolution that cannot be accomplished through simulation alone.