Geophysical Research Abstracts
Vol. 13, EGU2011-1118, 2011
EGU General Assembly 2011

Information Measures of Divergence, M-estimates and Minimum Contrast Estimation Approach and Its Application to Biophysical Parameter Estimation.

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Estimation of land-surface biophysical parameters from satellite data is one of the most challenging problems in remote sensing. Biophysical parameters such as leaf area index (LAI), fraction of photosynthtically active radiation absorbed by the vegetation canopy (fAPAR) and vegetation cover fraction (FC) affect the spectral properties and the directional dependency of solar radiation reflected at the land surface. Several approaches for the inversion of this problem exist. Most, if not all of these, use a least squares estimate to minimize the distance between model predictions and observations. However, little attention has been paid, to alternative distances/divergences that are found throughout the statistical literature. Least squares estimates (LSE) neglects the fact of non-linearity of the problem. We investigate different information measures, M-estimates and minimum contrast distances and study non-linearity and robustness of the errors by solving the corresponding optimization problem. This statistical method can not only be used for the estimation of parameters from remote sensing data but also in other numerical inversion problems in different areas of geophysics.

In the present study we use a look-up-table approach to estimate biophysical parameters from visible and near-infrared reflectance data. The bidirectional reflectance distribution function (BRDF) and look-up tables are simulated with a model of light interaction with vegetation canopies (FLIGHT),[1]. FLIGHT uses a Monte Carlo simulation of photon transport and represents complex vegetation structures as well as angular geometry. We implement different divergences/distances for estimation of LAI from MODIS reflectance data (MOD09GA) at 500 m resolution and compare these estimates with ground measurements taken from two sites: the Bigfoot and Valeri sites. The dominant land-cover types in these sites are conifer forest and broad lead forest. We find that LSE is not an optimal distance and that estimation of LAI can be improved with alternative measures, in some cases by up to 10%.

[1] P.R.J., North, Three-dimensional forest light interaction model using a Monte Carlo method, IEEE Transactions on Geoscience and Remote Sensing, Vol. 34, No. 5, (1996), 946-956.