Anais X SBSR, Foz do Iguaçu, 21-26 abril 2001, INPE, p. 1583, Sessão Técnica Oral - Workshops

DETECTION OF SELECTIVE LOGGING AND REGROWTH BY SAR AND LANDSAT

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Abstract:

The effects of tropical deforestation on the carbon budget are known to depend upon the land-use history of a given parcel of forest. A patch of primary forest may be clearcut in preparation for land-use conversion to agriculture or pasture or it may be selectively logged in order to remove merchantable timber. The selective logging may or may not be followed by subsequent clearcutting and land-use conversion. In all cases, logged areas may be subject to 'abandonment' with consequent regrowth and potentially leading to forest regeneration. Each pathway has different consequences with respect to the ultimate quantity of carbon removed/sequestered over time and the fate of the carbon thus exchanged.

Remote sensing techniques have been championed as a viable means to estimate the location and extent of tropical deforestation, to potentially quantify the amount of carbon removed, and to use the observed time-history to predict the nature and fate of the carbon exchange. The determination of clearcut areas by use of optical and radar techniques is fairly straightforward when provided with adequate spatial resolution relative to the patch size of the forest disturbance. Identification and quantification of selective logging is more problematic because of more stringent spatial resolution requirements and because the detectable 'signal' (tone and textural changes) may itself be faint or degrade rapidly with time as a response to rapid regeneration in tropical environments. The spatial resolution requirements are determined by the size distribution of 'patios' used for the collection and processing of logs or are even more stringent if one seeks to identify the 'gaps' in the crown related to the felling of individual trees. Signal degradation is related to velocity of regrowth after disturbance and seems to range from 1 to 4 years depending upon the nature of disturbance and local factors (e.g. soil, climate and floristic composition) that control regrowth processes.

This paper examines the use of Landsat data and repeat-pass interferometric SAR for detection of selective logging in the Mato Grosso province of Brazil. The study uses JERS-1 SAR data obtained over a 44-day period in 1994 (October and December) that brackets a November Landsat scene previously analyzed by INPE as part of a study to quantify selective logging history (1989 to 1998) over a number of study sites in the Amazon basin. This study tracks the time history of selective logging for 238 polygons that experienced some selective logging over the 10-year period as identified on Landsat data by INPE. The polygons are stratified into five general groups on the basis of their histories: (1) not logged, (2) those with selective logging commencing in 1994, (3) selectively logged continuously prior to SAR observation, (4) selectively logged followed by regrowth, and (5) selectively logged followed by clearcutting. We examine the SAR amplitude and multi-pass coherence as an alternative (or synergistic) method to detect selective logging. The probability density functions of optical and near-IR reflectance and radar backscatter and coherence are analyzed to test hypotheses that selective logging and the subsequent land-use pathways produce detectable signal response functions in the mean and variance. The pdfs are used to develop a machine classifier that first identifies non-forest classes, then identifies selective logging patios in the forested areas using a texture-based technique. The patios are buffered to account for the 'zone of collection' and a composite map of land use is generated. The results of the machine classification are compared to that obtained by manual interpretation of the Landsat imagery.

Keywords: Selective logging, radar, landsat, Amazon