MONITORING FLOODED AREA FRACTION IN FLOODPLAINS OF PARANÁ BASIN USING PASSIVE AND ACTIVE MICROWAVE SYSTEMS

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1. INTRODUCTION

Over the past two decades, orbital passive microwave systems have proven to be sensitive to flood condition in large floodplains. This sensitivity is rooted in the well differentiated emission properties of calm water with respect to non-flooded land of any kind. For bare soil (or calm water), the emissivity at vertical (V) polarization is higher than the one at horizontal (H) polarization. Basically, an increase of soil moisture produces a decrease of emissivity at both polarizations, and at all microwave frequencies. However, the effect is more important at H polarization and at the lower frequencies [1], [2], [3]. On its turn, the influence of vegetation is dependent on frequency, overall biomass and geometrical properties of vegetation elements [4]. On average, vegetation growth produces a decrease of the difference between vertically polarized and horizontally polarized emission.

Several studies were aimed at singling out vegetation effects from soil effects. It was found that the polarization difference at high frequencies (Ka band) was mostly related to vegetation emission, and showed a good correlation with vegetation indexes derived by optical instruments [5]. Therefore, further studies aimed to monitor soil condition adopted the lower frequencies available, typically X band. Moreover, in order to eliminate the dependence on surface temperature, a normalized polarization index (PI) [6] was defined as,

$$PI = \frac{T_{bv} - T_{bh}}{0.5(T_{bv} + T_{bh})} \quad (1)$$

where T_{bv} and T_{bh} are the brightness temperature values collected at vertical and horizontal polarization, respectively. Experimental studies, confirmed by a simple zero order radiative transfer model, demonstrated that this index is sensitive to vegetation biomass [2], [6]. A further parametric study, carried out by means of a discrete physical model, confirmed the main finding of experimental studies and pointed out that the same polarization index is also sensitive to soil condition, at least at frequencies lower than 10 GHz [7]. This dependence on soil condition was confirmed by an experimental analysis of C band signatures collected at global scale by the SMMR radiometer [8].

Passive signatures collected by SMMR and SSM/I instruments were exploited for flood monitoring applications. In these sensors, 37 GHz and 19 GHz channels were used, since lower frequencies were available only at very poor resolutions or not available at all. Although high frequencies suffer atmospheric effects and high canopy attenuation, valid results in some applications were obtained. In [9], the absolute polarization difference at 37 GHz proved to be sensitive to flooding effects occurred in the Amazon River. A simple algorithm, based on the polarization difference at 37 GHz measured by SMMR, was adopted to estimate the fraction of flooded area during several events occurred in the Amazon River and in other large South American rivers floodplains.

This algorithm is based on (1) a model of allowed pixel end-members and (2) an additive hypothesis about the emissivity of the footprint [9]. Using these hypothesis and several resourceful methods to estimate the emissivity of footprint end-members and their fractions, several estimations of wetland flooded area were published [10] [11]. These approaches worked well in areas where the pixel model chosen (open water, flooded land, non-flooded land), correctly represented the real situation at pixel scale. Furthermore, one of the strongest hypotheses of this approach is that the fraction of open water is a constant value and can be estimated independently.

2. RESULTS

Recently, we have analyzed AMSR-E signatures of the Paraná River basin during a large flood event [12]. Since we have found a strong correlation between PI and water level at several hydrometric stations, we have applied the algorithm developed in [10] for a region in the Paraná River Delta. For this area there is a general correspondence between the variations of flooded area and variations of measured water level [12]. In spite of the high frequency of the selected AMSR-E channel, the algorithm works well, because for the area considered, the dominant vegetation type is herbaceous (mostly wetlands, maximum vegetation height ~2m) and they were submerged during the flooding.

In this paper, a refined approach to estimate flooded area of the Paraná River Delta based on a more complex pixel model and passive-active synergy is presented. Based on a high resolution landcover map of the area [13], the pixel model now includes the five mayor pixel end-members present in the area (open water, flooded/non-flooded forest and flooded/non-flooded marsh) and a method to estimate their PIs and fractional area. Moreover, in this new approach, Envisat ASAR ScanSAR mode data is used to estimate flooded area using a simple change detection scheme. This high resolution information about flood condition is then used to recalibrate the passive estimate. In this way, we propose an algorithm to estimate the fraction of flooded area that combines the goodness of both methods: the high temporal resolution and coverage of passive systems and the high spatial resolution of active system (used for recalibration). In summary, we present a way to remove the most expected biases in the flooded area estimate: those due to changes in landcover (using a high resolution land cover map of the area) and those due to wrong/old estimations of flooded area (using high resolution SAR images).

This work is being carried out within the framework of an AO NASA-CONAE-MinCyt accepted project regarding the use of future SACD/Aquarius system for monitoring floods and droughts in La Plata basin [14].

3. REFERENCES

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