PASSIVE MICROWAVE REMOTE SENSING OF FLOODING IN THE PANTANAL

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The Pantanal is characterized by seasonal inundation of vast floodplains. Knowledge of the areal extent and seasonality of the flooding is required to understand the hydrology, biogeochemistry and ecology of the region. This information is also necessary for management decisions, and to identify the potential impacts of proposed development projects such as the Paraná-Paraguay Waterway (Hidrovia).

In contrast to optical systems, passive microwave remote sensing from satellites can detect inundation when clouds and vegetation are present. The polarized brightness temperatures observed by satellite at 37 GHz provide a sensitive indicator of the presence of surface water (Choudhury 1991). Passive microwave satellite observations are available from 1979 to the present, at intervals of weekly or better. These observations have been made by the Scanning Multichannel Microwave Radiometer (SMMR) operated on board the Nimbus-7 satellite (1979-1987), and by the Special Sensor Microwave/Imager (SSM/I) instruments as part of the Defense Meteorological Satellite Program (1987-present).

Passive microwave sensors measure the very faint natural emission of microwave energy from the Earth's surface and atmosphere. Their coarse spatial resolution compared to optical remote sensing systems results because the sensors must integrate the emission over a large area to yield a measurable signal (Lillesand and Kiefer 1994). The spatial resolution of the sensor is approximately 27 km at 37 GHz, and therefore a given measurement over floodplains is likely to contain a mixture of flooded land, dry land, lakes and rivers. However, by using linear mixing models which incorporate the major end-members of the observed microwave signatures, we are able to calculate the fraction of flooded land in each pixel over time. Our methods are detailed by Sippel *et al.* (1994) and Hamilton *et al.* (in review).

In this study, we analyze a monthly time-series of SMMR data (Choudhury 1991). We divided the Pantanal into 10 subregions with distinctive hydrology and geomorphology, based on field experience, consultation of Landsat TM images, radar maps (Brasil 1982), and the subregions described by Adámoli (1982). We selected only 3 subregions to present here. A complete analysis of the Pantanal SMMR data set is presented in Hamilton *et al.* (in review). Time series for the 9-year SMMR observation period illustrate differences among subregions in the seasonal and interannual variability of inundation area (Figure 1). The Cuiabá subregion in the northern Pantanal (total area, 14400 km^2) flooded to >80% during 6 of the 9 years in the study. The Nhecolândia subregion (8600 km^2), which contains thousands of hydrologically distinct small lakes ('baias"), had less area flooded annually but did not dry as much at low water since many of the small lakes retain water throughout the year. The extent of flooding in the southernmost subregion, Nabileque (13660 km^2), was quite variable from year to year.

Differences in the timing of the inundation peaks among subregions are readily visible by comparing the monthly means from the SMMR time series (Figure 2). Peak rainfall tends to occur from November-March in most of the Pantanal. The monthly means in Figure 2 show that floodplain inundation tends to peak from 2-6 months after the peak rainfall. There is a general progression of the flood wave from the northern and eastern parts of the Pantanal towards the Paraguay River with the most delayed flooding in the Nabileque subregion, where maximum inundation corresponds with the beginning of the local dry season.

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References

Adámoli, J., O Pantanal e suas relações fitogeográficas com os cerrados: Discussão sobre o conceito de "Complexo do Pantanal", *Anais do XXXII Congresso Nacional de Botânica*, Federal University of Piauí, Teresina, Brazil, pp. 109-119, 1982.

Brazil. Projeto RADAMBRASIL, Levantamento de Recursos Naturais, Volume 27, Folha SE.21 Corumbá e Parte da Folha SE.20, Ministerio das Minas e Energia, Brasília, 1982.

Choudhury, B.J., Passive microwave remote sensing contribution to hydrological variables, *Surveys in Geophysics* 12, 63-84, 1991.

Hamilton, S.K., Sippel, S.J., Melack, J.M. Inundation patterns in the Pantanal wetland of South America determined from passive microwave remote sensing. *In review*.

Lillesand, T.M., and Kiefer, R.W., *Remote Sensing and Image Interpretation*, John Wiley, New York, 1994.

Sippel, S.J., Hamilton, S.K., and Melack, J.M., Determination of inundation area in the Amazon River floodplain using the SMMR 37 GHz polarization difference, *Remote Sensing of Environment*, 48, 70-76, 1994.

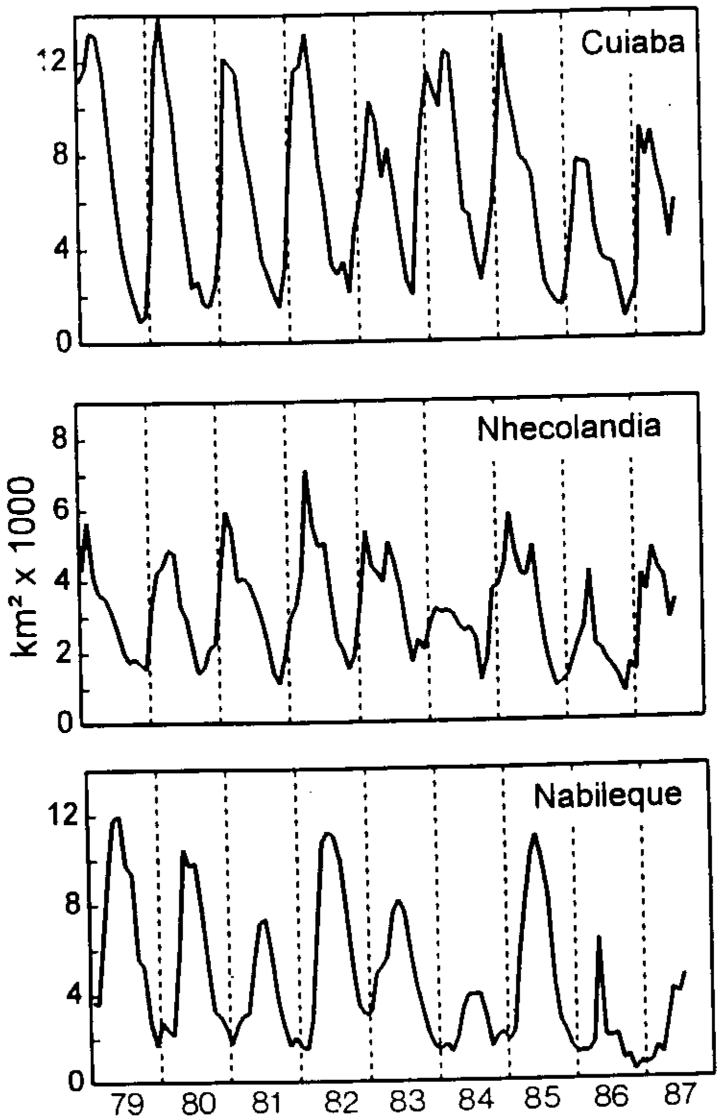

Figure 1. Monthly estimates of inundation area for three subregions of the Pantanal, derived from the 1979-87 SMMR observations.

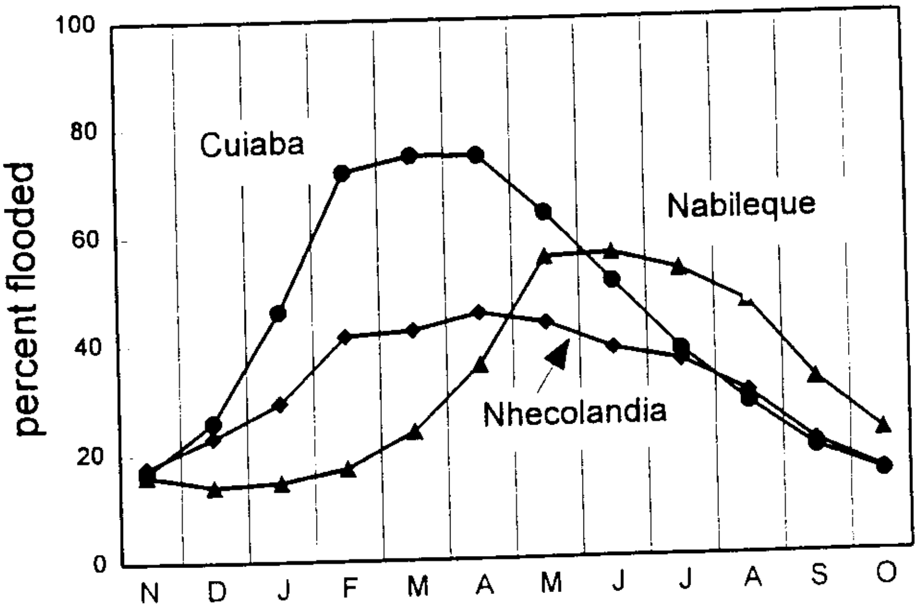

Figure 2. Annual cycle of inundation area for three subregions of the Pantanal, derived from the 9-year time series in Fig.1.