Water balance for the Ji-Paraná Basin using remote sensing and GIS

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Introduction

The water cycle is essential for the functioning of the Amazon ecosystem. It's responsible, not only for 35 to 50 % of the precipitation, but also it acts as the transport mechanism of almost all biogeochemical cycles.

The growing change in land use and cover that's happening in the state of Rondônia, especially in the Ji-Paraná basin, could result in changes in various ecosystem components, including the water balance and all biogeochemical cycles.

Hydrological models are widely used to understand the effects of deforestation on the water balance, but most of them need a great amount of input parameters and forcing variables, which are seldom available.

Here we present a simple and fast method to estimate the monthly water balance of a watershed, based on the well known Thornthwaite – Mather water balance, together with the Thornthwaite potential evapotranspiration estimate, inserted into a GIS environment.

This approach has the advantage of being very simple, requiring a small amount of input parameters and variables: 1) mean monthly temperature, 2) precipitation, 3) soil texture and 4) root depth.

Mean monthly temperature was estimated through AVHRR monthly composite images at 1 km resolution. Precipitation was obtained from daily rain gages from the "Agencia Nacional das Águas" (ANA). Soil texture was acquired by interpolating soil profiles from the basin and root depth was estimated according to the land cover.

Material and Methods

The basic model flow is described below and shown in Figure 1.

1. Daily AVHRR images are clod screened and average over a month in order to produce mean monthly temperature composite images (Figure 4 and 5)
2. Potential Evapotranspiration is calculated from mean monthly temperature images, using Thornthwaite's method
3. Monthly precipitation surface is interpolated from precipitation stations (Figure 2), using the Inverse Distance Weighting method (power = 2)
4. Root depth, estimated from the land cover map, and soil texture were geostatistically interpolated from the SIGTERON database, are used to compute soil storage capacity (Figure 6)
5. Precipitation and Potential Evapotranspiration surfaces are the inputs of the model. Figure 3 describes the water balance model used.

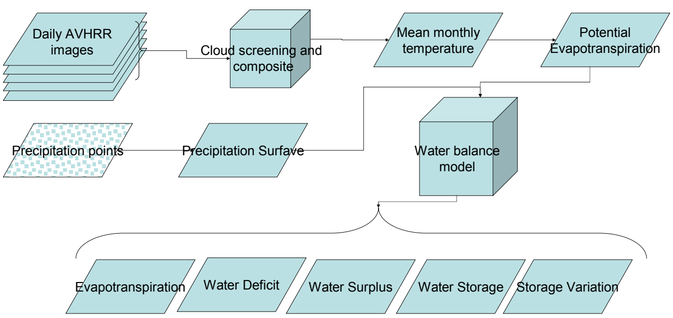

Fig 1. Model data flow

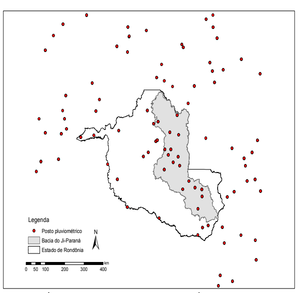

Fig 2. Pluviometric stations used

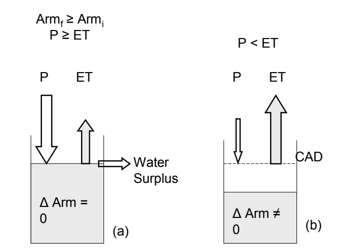

Fig 3. Water balance Model (a) Precipitation higher then potential evapotranspiration and storage capacity filled results in water surplus. b) Water input is less then potential evapotranspiration. Water is removed from storage and evapotranspiration is less than potential (SOURCE: Tateishi, 1996)

Results

The monthly water balance for the Ji-Paraná is presented in Figure 7. From this figure we see clearly that there is a water deficit period in this region.

The model output can also be analyzed spatially (Fig 9 and 10).

Modeled ET and water surplus is compared with measured discharge and ET calculated from an annual water balance for 10 sub-basins. Modeled ET is under predicted but better estimates of soil water storage can correct this problem (Fig 11 and 12).

Three scenarios are tested, one were all forest was removed, and two with no deforestation and different root depths (2 and 5m). Model output is strongly influenced by these changes, affecting not only water deficit and surplus but also, basin wide ET (Figs 13 through 16).

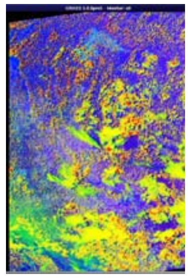

Fig 4. AVHRR color composite (bands 2, 4, and 3-4) over Ji-Paraná basin for march 1995.

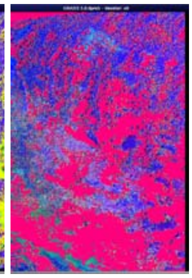

Fig 5. Cloud screening of color composite

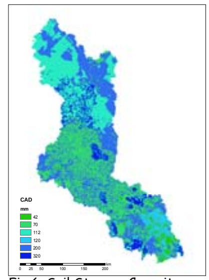

Fig 6. Soil Storage Capacity

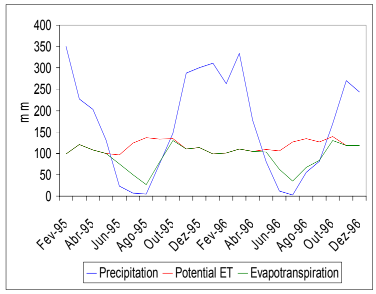

Fig 7. Average water balance for the Ji-Paraná basin

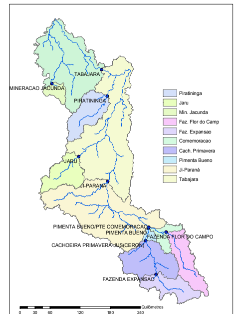

Fig 8. Sub-basins used to check water balance

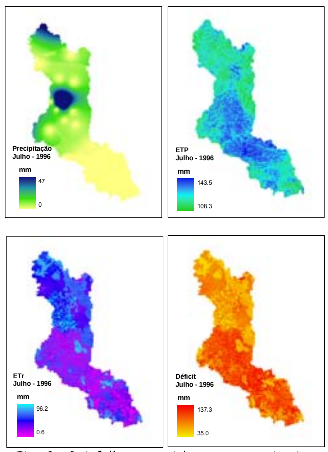

Fig 9. Rainfall, potential evapotranspiration, evapotranspiration and water deficit and surplus for July 1996

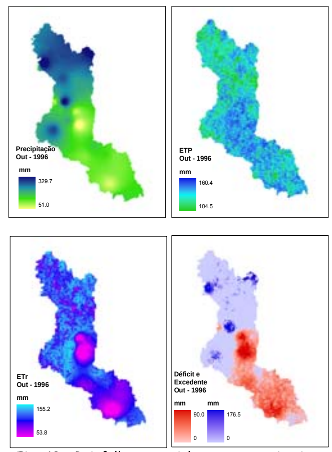

Fig 10. Rainfall, potential evapotranspiration, evapotranspiration and water deficit and surplus for October 1996

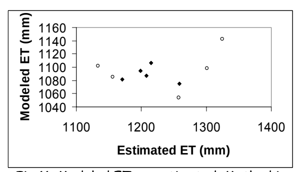

Fig 11. Modeled ET vs. estimated. Method is under predicting ET

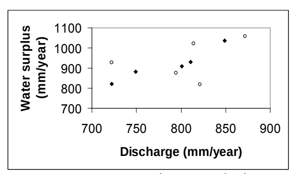

Fig 12. Water surplus vs. discharge. Method is over predicting

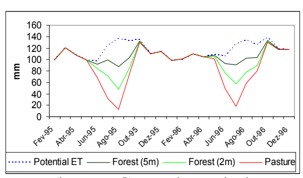

Fig 13. Changes in ET over distinct land covers

Conclusions

This very simple model was able to estimate the monthly water balance for the Ji-Paraná basin, using a very limited number of variables.

Soil water storage greatly influence the model and cam be used to calibrate the output, and also as a simulation of deforestation scenarios.

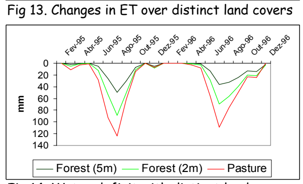

Fig 14. Water deficit with distinct land covers

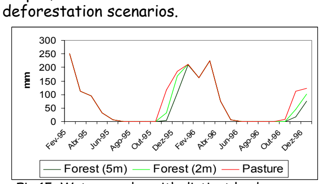

Fig 15. Water surplus with distinct land covers

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