departures from median rainfall. The underlying effect that triggers the onset of rainfall events is highly seasonal, and is dependent on the global circulation dynamics. When deviation effects occur, these positive or negative regions enlarge.

Deviations were detected in approximately 50% of the months (P<.05).The negative deviations are more intense and more continuous spatially, while the positive deviations are wider and weaker and more randomly distributed. A high spatial correlation of monthly rainfall was found. Even for months with no evidence of deviations, some continuous regions received rainfall above medians and were balanced by another region receiving rainfall below medians.

REFERENCES

Aceituno, P. 1988: On the functioning of the Southern Oscillation in the South American sector. Part I: Surface Climate.

Mon. Wea. Rev., 116:505-524. Bjerknes, J. 1969: Atmospheric teleconnection from the Equatorial Pacific.

Mon. Wea. Rev., 97:163-172. Cane, M. A. 1983: Oceanographic events during El Niño. *Science*, 222:1189-1195.

Gamma Design Software. 1994. *Gs+: Geostatistics for the environmental science*. Gamma Design Software, 133 pp.

Gibbons, J. D. 1985: *Nonparametric Methods for Quantitative Analysis*. 2d ed. American Sciences Press, 481 pp.
Hartmann, D. L. 1994: *Global physical climatology*.

Academic Press, San Diego, CA. Hartmann, D. and J. R. Gross. 1988: Seasonal variability of the 40-50 day oscillation in wind and rainfall in the tropics. *J. Atmos. Sc.*, 45:2680-2702.

Hastenrath, S. 1984: Interannual variability and annual cycle: Mechanisms of circulation and climate in the Tropical Atlantic Sector.

Mon. Wea. Rev., 112:1097-1107. Kiladiz, G. N. and H. F. Diaz. 1989: Global climatic anomalies associated with extremes in the Southern Oscillation. *J. Climate*, 2:1069-1090.

Kousky, V. E., M. T. Kagano, and I. F. A. Cavalcanti. 1984: A review of the Southern Oscillation: oceanic-atmospheric circulation changes and related rainfall anomalies. *Tellus*, 36A:490-504.

Krishnamurti, T. N. and D. Subrahmanyam. 1982: The 30-50 day mode at 850 mb during MONEX. *J. Atmos. Sc.*, 39:2088-2095.

Madden, R. A. and P. R. Julian. 1972. Description of global-scale circulation cells in the tropics with a 40-50 day period. *J. Atmos. Sci.*, 29:1109-1123.

Marengo, J. A. 1992: Interannual variability of surface climate in the Amazon basin. *Int. J. climatol.*, 12:853-863.

Marengo, J. A. and S. Hastenrath. 1993: Case studies of extreme climatic events in the Amazon basin. *J. Climate*, 6:617-627.

Matalas, N. C. 1991: Drought description. *Stoch. Hydrol. Hydraul.*, 5:255-260.

Rao, V. B. and K. Hada. 1990: Characteristics of rainfall over Brazil: Annual variations and connections with the Southern Oscillation. *Theor. Appl. Climatol.*, 42:81-91.

Rasmusson, E. M. and J. M. Wallace. 1983. Meteorological aspects of the El Niño/Southern Oscillation. *Science*, 222:1195-1202.

Ropelewski, C. F. and M. S. Halpert. 1987: Global and regional scale precipitation patterns associated with the El Niño/Southern Oscillation. *Mon. Wea. Rev.*, 115:1606-1626.

UNESCO. 1978: *World water balance and water resources of the earth*.

UNESCO Press, Paris. Wyrtki, K. 1975: El Niño—The dynamic response of the Equatorial Pacific Ocean to atmospheric forcing. *J. Phys. Oceanogr.*, 5:572-584.

ANALYSIS OF RAINFALL DISTRIBUTION IN THE AMAZON BASIN USING KRIGING, NONPARAMETRIC STATISTICS, AND GIS TECHNIQUES. III. ATMOSPHERIC WATER BALANCE.

Elson D. Silva[1], Researcher Scientist, Ph. D.
Brazilian Enterprise for Agricultural Research, Satellite Monitoring Center (Embrapa-NMA)
Gary W. Petersen, Soil Scientist, Ph.D., Prof. of Soil and Land Resources
Agronomy Dept., The Pennsylvania State University.

A water balance refers to the balance that must exist among water entering the basin (input), water leaving the basin (output), and water being stored. The main components of the water balance are precipitation (P), evapotranspiration (ET), and streamflow (R).

River flow is calculated using measurements at gauging stations situated close to the river mouths. Measurement of stream flow at the mouth of the Amazon River is almost impossible, however, because it has multiple distributary branches, a large delta, and is influenced by ocean tides. Most studies in the Amazon River gauge streamflow near the city of Óbidos, around 800 km upstream from the mouth, and extrapolate to the entire basin.

Precipitation within the Amazon Basin is known to originate from the recycling of water vapor released during ET and from the moisture influx into the basin. It is suggested that a reduction in tropical forests may result in reduced evaporation and rainfall.

UNESCO (1978) has developed one of the most accurate water budgets for the Amazon Basin. This water budget reports a total of 2150 mm y^{-1} of precipitation, 1060 mm y^{-1} of evaporation, and 1000 mm y^{-1} of river discharge for an area of 6,915,000 km^2. These estimates can be improved using a more sophisticated data analysis of more extensive rainfall data sets. Nonparametric statistics can be used to assess typical values (medians), to protect against potential mistakes, or erratic values, and to detect centrality in skewed distribution. GIS techniques handle raster and vector spatial information and its gridding capabilities allow partitioning of water balance components into squared cells. The goal of this study was to develop an atmospheric water balance for the Amazon Basin (6,860,350 km^2) using 533 weather stations, more advanced geostatistical techniques for surface interpolation (kriging), and a robust nonparametric statistical analysis.

This work can be used as a reference base for any scientific application concerning the water cycle in the Amazon Basin. The spatial distribution of the water balance components can be useful in the study of ecosystem dynamics in the tropics and can allow for a comparison of spatial water balance to the vegetation distribution in the Brazilian Amazon.

[1] Av. Dr. Júlio Soares de Arruda, 803, Parque São Quirino, 13088-300, Campinas, SP, email: **silva@nma.embrapa.br**.
Disclaim notice: The views expressed in this article are the author's and do not necessarily represent the official policy or interpretations of the Brazilian Enterprise for Agricultural Research (Embrapa).